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MEASUREMENTS OF UTERINE CONTRACTIONS IN LATE PREGNANCY

A Study of Five Patients with the Lóránd Tocograph

DOUGLAS P. MURPHY, M.D, F.A.C.S., Philadelphia, Pennsylvania

INADEQUATE uterine power continues to be one of the commonest causes of difficult labor. One method of attacking this problem would seem to lie in securing a better understanding of the characteristics of the uterine movements themselves. It would appear not unlikely that there might be some sequential relationship between the prelabor and the labor contractions. With these ideas in mind a study is being made of the uterine activity both before and during labor. The present report concerns the former; it deals with the magnitude of the movements which take place during the last 2 months of pregnancy, and especially with the changes which they exhibit as labor is approached.

LITERATURE

A number of techniques have been devised for the purpose of recording the nature of the uterine movements. Kristeller estimated indirectly the amount of force necessary to expel the fetus by utilizing a dynamometer in the handles of an obstetrical forceps. Poppel measured it in terms of the amount of force required to rupture amniotic membrane.

From the Gynecean Hospital Institute of Gynecologic Research, and Department of Obstetrics and Gynecology, University of Pennsylvania.

Schatz determined the intra-uterine pressure directly with a rubber balloon inserted into the laboring uterus. Poullet combined a rectal balloon with the uterine balloon of Schatz, in order to measure the extra-uterine pressure created by the contraction of the abdominal muscles. Since the direct method involved the invasion of the uterus during labor, it was obviously impractical, if for no other reason than because of the danger of sepsis. This objection, among others, led to the search for a more practical method.

Schaeffer was the first observer to record the uterine movements mechanically through the medium of the abdominal wall. He applied an air-inflated, dome-shaped apparatus to the abdomen which was connected to a recording device. Ruebsamen registered the changes in the contour of the abdominal wall by placing upon it a 500 gram weight connected with a recording lever by means of a piece of string. Crodel appears to have been the first observer to pick up the abdominal movements by means of a movable metal rod and lever arrangement. Dodek placed a rod between the abdomen and an air-filled tambour, making permanent records upon a smoked kymograph paper. Frey, using the rod and lever principle, secured a permanent record

with ink, the tracing taking a circular direction. Rech interposed an electrical system between the apparatus which picked up the abdominal movements and the recording device. Lóránd (5, 6) improved upon Frey's method by having his permanent record in a lineal rather than in a circular direction. He has constructed 3 different tocographs, the second of which was used for the present study.

MATERIALS AND METHODS

Recording device. The Lóránd tocograph, which was employed in the present study (6), consists of a set of levers enclosed in a metal box 9.5 by 11 centimeters square, by 6 centimeters high. It is fastened to the abdomen with an elastic belt. Changes in the contour of the abdominal wall, which take place with each uterine contraction, are registered by a movable, metal rod, 6 millimeters in diameter, which, when at rest, projects 5 millimeters from the bottom of the box. The rod, requiring a weight of approximately 150 grams to displace it, operates a writing point at right angles to a strip of millimeter, cross-section paper, the latter being moved by clockwork at the rate of 1 millimeter in 12 seconds. The excursion of the pen is 7 times greater than that of the rod in contact with the abdomen.

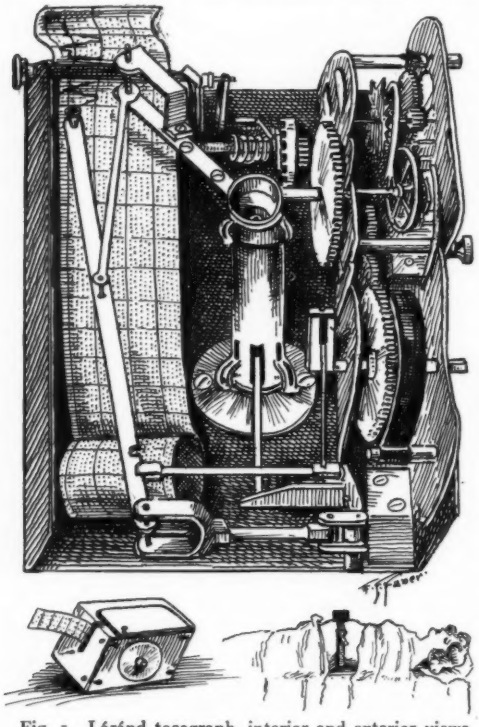

Fig. 1. Lóránd tocograph, interior and exterior views, and in position for recording. Movable button protruding from bottom of tocograph (lower left), operates system of levers, which move writing point at right angles to strip of cross-section paper, which in turn is motivated by clockwork.

Method of securing records. Patients attending the prenatal clinic of the Hospital of the University of Pennsylvania acted as subjects. They were selected at random except for the fact they were primagravidas and at least 32 weeks pregnant at the start of the study.

All records of a patient were made at her home and each tracing was secured at the same time of day. For the recording she assumed the semi-recumbent posture with her shoulders supported by a felt pillow. After a rest period of 10 minutes the tocograph was strapped to her abdomen, cephalad, but close to the umbilicus. Each tracing period lasted 1 hour during which time the patient reported the sensation which accompanied any intra-abdominal movement. Each patient was observed on an average of 3 times a week, the last tracing being made a day or two before the onset of labor. Five women were studied, 1 for 8 weeks, 2 for 7, 1 for 5, and 1 for 3 weeks. One hundred six daily records were secured; these represented approximately 120 hours of observation and registered 1,377 uterine contractions.

RESULTS

Observations made during the recording period. The tocograph recorded sneezing, coughing, vomiting, laughing, fetal movement, and uterine contractions, but did not pick up maternal respiration or intestinal action. With the patient quiet only uterine contractions and fetal movements were registered; the former created waves, and the latter, vertical lines upon the tracing paper.

Many uterine contractions were accompanied by a sensation of tightness in the abdomen; its degree was in proportion to the height of the recorded wave and the tenseness of the abdomen.

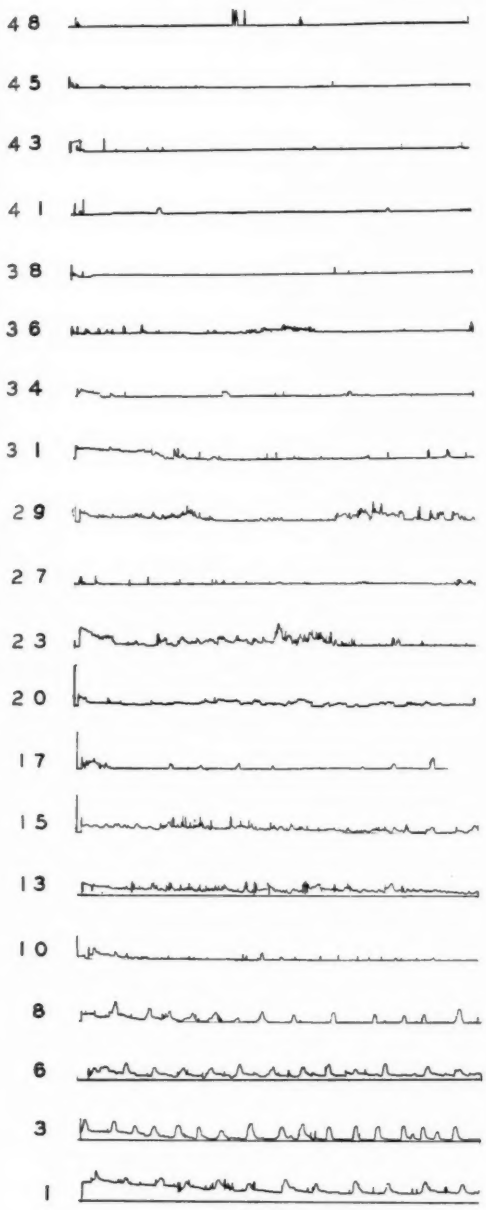

Fig. 2

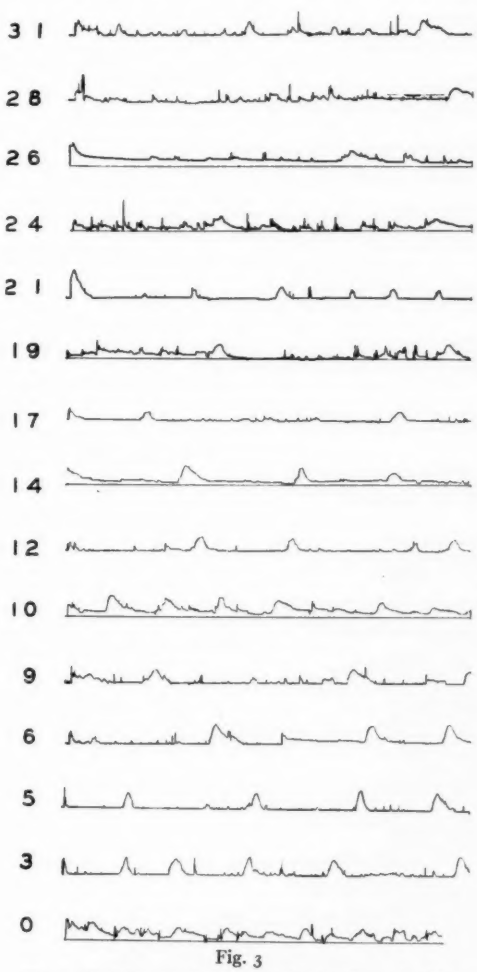

Fig. 3

Fig. 2. Prelabor uterine contraction tracings of subject, F. M. (Table I). Read from left; each tracing represents approximately 1 hour's observation; numerals indicate the number of days intervening before labor; vertical thrusts represent fetal movements; waves register uterine contractions. Note (a) general resemblance of tracings from day to day, (b) increase of uterine activity as labor is approached, and (c) the onset of rhythmic contractions 8 days before labor. Picture one twenty-fourth actual size.

Fig. 3. Prelabor uterine contraction tracings of subject, G. T. (Table I). Description same as for Figure 2. Note (a) similarity of tracings from day to day, and (b) appearance of large waves as early as 31 days before labor.

General character of tracings. The general appearance of the tracings is exemplified by those of patients F. M. and G. T. reproduced in Figures 2 and 3. The numerals at the left indicate the number of days between the re-

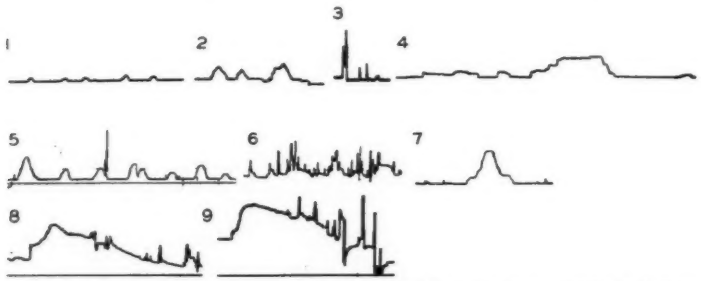

Fig. 4. Uterine contraction waves of subject, M. R., *1* and *2*, very small and large waves, forty-ninth day before labor; *3*, fetal movement, forty-fifth day; *4*, large waves showing step formation, thirtieth day; *5*, large waves with strong fetal movement, twenty-third day; *6*, active fetal movement sixteenth day; *7*, symmetrical step formation, tenth day; *8*, strong uterine contractions with prolongation of fall of wave, seventh day; *9*, same as *8* but with even greater uterine tension between waves, i.e., valley level at start of wave well above base line.

cording of the tracings and the onset of labor. The sharp thrusts due to fetal movement are readily distinguishable from the slower waves which are the result of uterine contractions.

Patient F. M. (Fig. 2) exhibited little uterine activity until 8 days before labor, when her uterine waves became very rhythmic in appearance.

Patient G. T. (Fig. 3), on the other hand, showed a considerable degree of uterine activity as early as 31 days before labor.

Each of the 5 patients exhibited a distinctive contraction pattern. The similarity in the appearance of the various tracings of any one patient, and the dissimilarity between the patterns of different persons, represent 2 of the most significant observations arising from the present study.

General characteristics of the uterine contractions. In a general way the waves created by uterine contractions can be classified in 2 categories, depending upon the duration of pregnancy at the time that they are recorded: (a) waves registered before the fortieth week of pregnancy, and (b) those recorded during the fortieth week.

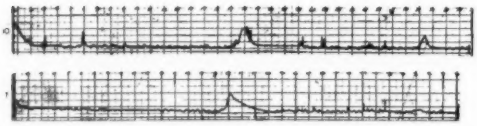

Fig. 5. Prelabor uterine contraction tracings of subject, S. T., (Table I). Description same as for Figure 2. Note series of small waves, uniform in height, duration, and occurring at regular intervals, immediately preceding a large wave. With these small waves the patient experienced a "rolling" sensation. The small waves are about 1 millimeter in height, and therefore represent changes in the abdominal wall contour of only one-seventh of that amount.

Contractions registered before the fortieth week. Waves observed at this time were characterized primarily by arrhythmia, and by variations both in shape and magnitude (Fig. 4). Two sizes of waves were observed, large and small.

The small waves were seen only in the period before the fortieth week. They were more numerous than the large ones, more uniform in size and shape, and had a tendency to occur in groups. In many cases these small waves immediately preceded a large wave (Fig. 5). The small waves shown in the latter figure were usually associated with what the patient described as a "rolling" sensation.

The large waves were much less frequent than the small waves and came at more irregular intervals. They were greater in all dimensions than the small waves, and had a strong tendency to rise and fall in "steps" (Fig. 4, tracings 4 and 7), the latter being variable in number, position, height, and breadth.

Contractions recorded during the fortieth week. About the beginning of the last week of pregnancy a change in the wave picture was usually observed. This is demonstrated in the eighth day tracing shown in Figure 2. At this time the so called large waves of the earlier period increased in frequency and height, became more uniform in size, and took place

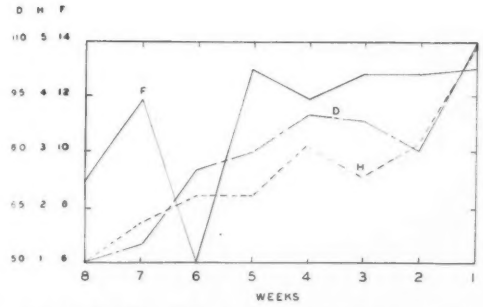

Fig. 6. Base line represents weeks intervening between recording of contractions and onset of labor. Vertical line records average values for duration, *D*, height, *H*, and frequency, *F*, of uterine contraction waves; data taken from Table II. Note increase in all measurements as labor is approached and the unusual increase in the height and duration of the waves during the week immediately preceding labor.

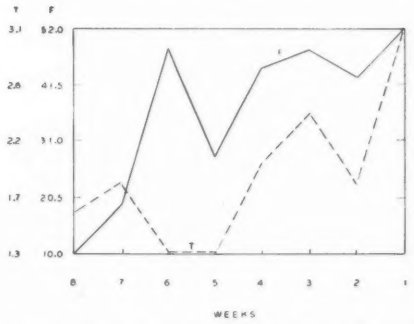

Fig. 7. Base line represents weeks intervening between recording of contractions and onset of labor. Vertical line records the percentage of uterine contractions felt by patient, *F*, and the average distance of tracing from base line (tension of uterus), *T*; data taken from Table II. Note the increase of both characteristics as labor is approached, and the unusual increase in tension during the week immediately before the onset of labor.

at more regular intervals. The rise and fall of these waves usually were equal in duration, but there was a tendency for the fall to be longer than the rise (Fig. 4). In some cases the fall lasted several minutes.

MEASUREMENTS OF CONTRACTIONS

Each of the 1,377 uterine contraction waves was measured, a summary of which appears in Tables I and II. The first table lists the average values of these measurements by patients; the second table groups these contractions according to the number of days which elapsed between the recording and the onset of labor.

MEASUREMENTS OF CONTRACTIONS BY PATIENTS

Frequency. Of the 106 daily tracings, 2 failed to record any uterine activity; these 2 records were obtained from the same patient, 1 during the sixth week and 1 in the seventh week prior to labor. The average frequency of contractions for the 5 women (Table I) was 11.1 ± 6.0 per hour, with a coefficient of variation of .540, and a range between 1 and 38 hours.

Strength. The strength of contraction can be measured best as the height of the wave, though the relationship between the two is not known. However, the height of the wave

TABLE I.—UTERINE CONTRACTIONS INDEPENDENT OF INTERVAL BEFORE LABOR[1]

Patient	Daily records	Observation time hrs. min.	Contractions														Tension
			Recorded	Felt %	Frequency			Strength			Duration			Interval				
					Weight mean p/hour	Maximum p/hour	Minimum p/hr.	Weight mean mm.	Maximum mm.	Minimum mm.	Weight mean sec.	Maximum sec.	Minimum sec.	Total	Weight mean sec.	Maximum sec.	Minimum sec.	mm.
M. R.	35	41 8	396	43	10.3±5.5	13	6	3.5±2.0	13.0	0.3	110±57	714	6	360	299±159	1272	24	1.8
S. T.	29	32 40	497	14	14.4±9.2	38	1	1.4±1.7	12.8	0.1	54±45	636	1	468	183±145	1847	6	4.1
F. M.	20	22 04	208	73	9.1±5.5	21	0	4.1±2.0	14.2	0.2	93±61	684	12	190	260±128	1770	42	1.2
G. T.	14	15 16	194	55	12.9±5.5	30	6	4.1±3.3	18.0	0.2	104±88	660	4	185	240±175	1212	24	0.7
M. C.	8	8 46	82	54	9.1±4.5	15	1	3.2±2.2	16.2	0.2	66±55	194	2	87	233±173	1165	25	1.0

[1] Recording the averages for all measurements of the uterine tracings of five individuals. Felt contractions refer to those of which the patient was conscious. Tension refers to the distance of the valley level above the base line. Note the large standard deviation, and the wide range between minimum and maximum figures for all characteristics.

TABLE II.—CONTRACTIONS IN RELATION TO ONSET OF LABOR[1]

Days before labor	Persons studied	Daily records	Duration of observation hr.	Duration of observation min.	Contractions						Tension mm.
					Recorded	Felt per cent	Frequency p/hr.	Weighted mean			
								Height mm.	Duration sec.	Interval sec.	
50–56 inc.	1	4	4	41	42	10	9.0	1.0±0.6	50±36	244±210	1.6
43–49 inc.	3	14	15	41	185	19	11.8	1.7±0.9	55±44	430±115	1.8
36–42 inc.	3	13	14	21	88	48	6.1	2.4±1.5	74±29	393±173	1.3
29–35 inc.	4	13	14	31	188	28	12.9	2.4±2.0	79±66	238±148	1.3
22–28 inc.	4	13	14	22	172	44	11.9	3.2±1.9	90±65	260±167	2.0
15–21 inc.	5	14	15	24	197	48	12.8	2.5±2.0	87±58	237±130	2.4
8–14 inc.	5	17	19	56	255	44	12.8	3.1±2.5	80±54	239±223	1.8
1– 7 inc.	5	18	20	58	250	52	13.0	4.8±3.3	109±76	265±151	3.1

[1]Recording the averages for all measurements of the uterine tracings of the five individuals listed in Table 1, arranged according to the interval in days between the recording and the onset of labor. Note the increase in the measurements as labor was approached.

was found to be in proportion to the strength of the associated subjective sensation and to the tenseness of the uterus. The height of the average wave was 3.2±2.2 millimeters, with a coefficient of variation of .668, and a range varying between 0.1 millimeter and 16.2 millimeters.

Duration. The duration of the average wave was 85±61 seconds, with a coefficient of variation of .716, and a range between 1 second and 11 minutes and 54 seconds.

Interval. The average interval from the start of one wave to the beginning of the next was 243±156 seconds, with a coefficient of variation of .642, and a range between 6 seconds and 30 minutes and 47 seconds.

Contractions felt by patients. The 5 patients were conscious on the average of only 47 per cent of the recorded contractions. This figure included both the very small as well as the large contractions. One woman felt only 14 per cent, while another was conscious of about 73 per cent.

MEASUREMENTS OF CONTRACTIONS IN RELATION TO THE ONSET OF LABOR

There was a progressive increase in uterine activity as labor approached (Table II, Figs. 6 and 7), with an unusual increase during the last week or 10 days of pregnancy. The latter increase in the number of contractions occurred before there was any clinical evidence that labor had begun.

Contractions felt by patients. Contractions were felt by the patients as early as 56 days before labor (Table II); the proportion, however, was relatively small until the forty-second day. As labor approached there was a progressive increase in the number of contractions felt (Table II and Fig. 7). This increase was greatest during the last week of pregnancy, but was not in proportion to the increases in the measurements of the contractions.

Tension of uterus. The mean level of the valleys between the uterine contraction waves varied in the different individuals. When the abdominal wall was soft, the level of the valleys coincided with the base line; when tense, it remained above the line. The average distance from base line to valley level was secured by taking measurements at 5 minute intervals on each tracing, the result being recorded in millimeters (Tables I and II, and Fig. 7). The tension varied from day to day but in general increased as labor was approached; it was highest the week before labor.

SUMMARY AND CONCLUSIONS

1. The uterine contractions of 5 women, each pregnant for the first time, were registered by means of a Lóránd tocograph at intervals of several days throughout the last 2 months of pregnancy.

2. One hundred six records, each representing at least one hour's observation, and total-

ling 120 hours of recording, gave 1,377 uterine contraction waves for measurement and comparison.

3. The general character of the uterine contractions in a given patient tended to follow the same pattern from day to day.

4. The contraction patterns of the patients differed widely in their various characteristics.

5. The average frequency of contractions was 11.1 ± 6.0 per hour, with a range from 0 to 38 per hour.

6. The height of the average wave produced by a uterine contraction was 3.2 ± 2.2 millimeters, with a range from 0.1 to 16.2 millimeters.

7. The average duration of the contractions was 85 ± 61 seconds, with a range between 1 second and 11 minutes and 54 seconds.

8. The average interval from the start of one contraction to the beginning of the next was 243 ± 156 seconds, with a range between 6 seconds and 30 minutes and 47 seconds.

9. The patients were conscious of approximately 47 per cent of recorded contractions; one subject felt only 14 per cent, and another experienced 73 per cent.

10. As labor approached progressive increases were observed in the measurements of the following characteristics of uterine motility: (a) the strength, duration, and frequency of uterine contraction; (b) the percentage of contractions which were felt by the patient; and (c) the tension of the uterus. An unusual increase in the measurements of each of these qualities with the exception of "frequency" was observed during the week or 10 days immediately preceding the onset of labor.

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ENDOMETRIOSIS OF THE SIGMOID, RECTOSIGMOID AND RECTUM

CHARLES W. MAYO, M. D., F.A.C.S., and JOSEPH M. MILLER, M.D.,
Rochester, Minnesota

FIRST described as an entity by von Rokitansky in 1860, endometrioma, or adenomyoma, has remained an enigma which invites investigation because of its pathological and physiological features. In general, an endometrioma may be considered a tumor composed of aberrant endometrial cells associated with smooth muscle cells in some situations. The condition is found in the vast majority of cases at some period between the onset and the cessation of the menstrual function, and the epithelium undergoes the same physiological response to the action of ovarian hormones as does the normal mucosa of the uterus.

The lesion has been found in the form of a single tumor or formations of multiple tumors or dense infiltrations in a number of different situations including the sigmoid flexure of the colon, the rectovaginal septum, and the rectum. The practical importance of differentiation of such tumors from carcinoma and the inflammatory conditions of the bowel is easily realized. Endometriosis of the lower portion of the intestinal tract occurs somewhat more frequently than is commonly supposed. Sampson (6-10) found 13 "intestinal implants" in 64 cases. In one instance, the small intestine and sigmoid flexure were involved; in another, the cecum was involved; in the remainder, the rectosigmoid. Polster, in a collective review, reported 80 cases involving the bowel and 90 cases involving the rectovaginal septum.

Known considerations which are offered to help in arriving at a correct differentiation when the bowel is involved, are these: (1) endometriomas occur in females, usually between the age of 30 years and the menopause; (2) the longer the duration of the condition, the greater the chance is that a non-malignant lesion exists; (3) the general health of the patient is better and loss of weight does not occur so frequently when an endometrioma is present as when some other malignant lesion is present; (4) dysmenorrhea is a common complaint; (5) symptoms may have a definite rhythm, being present only at, or accentuated during, the menstrual period, whereas carcinoma and inflammatory conditions produce no such periodic symptoms; (6) sterility is often present; (7) slight to marked constipation, with periodic accentuation, is often one of the prime complaints, and this may progress to a more or less complete intestinal obstruction, according to the severity of the condition. Sampson's (6) patient suffered from constipation which gradually increased in severity for a period of 2 years, and attacks were most severe at the menstrual period; the abdomen became distended and nausea and vomiting were present; (8) diarrhea is less frequently observed but Cullen refers to a patient who had diarrhea concomitant with the beginning of her menstrual period, and who later suffered from pain in the lower part of the bowel 24 hours before the onset of menstruation and who experienced melena; (9) occult or fresh blood in the stools is more common in the malignant than in the benign states, and in some cases of endometrioma, bleeding was present only during menstruation, being infrequent, however, since endometriosis rarely involves the mucosa of the lower bowel; (10) pain on defecation is frequently present when an adenomyoma of the rectovaginal septum projects into the lumen of the rectosigmoid or the rectum, and this pain may be present only during menstruation; (11) results of proctoscopic examination are either negative or reveal a mass which is not primary in the wall of the bowel, pushing into it from without; if a tumor is seen, biopsy often will aid in the diagnosis; (12) roentgenographic investigation may help, in that the filling defects caused by endometriomas may be difficult to diagnose since they

From the Division of Surgery, The Mayo Clinic, and the Section of Surgery, The Mayo Foundation.

exhibit nothing distinctive, whereas carcinoma or the inflammatory states may produce a clear-cut picture.

However, the symptoms and signs presented in any individual case may vary considerably from the aforementioned pattern. At times a diagnosis cannot be made, even when the abdomen is surgically explored and the involved segment of bowel is brought into the wound. The gross resemblance of an endometrioma of the sigmoid flexure to a scirrhous carcinoma in an early state of development is at times remarkable. The peritoneal surface may be puckered and scarred in the presence of both conditions. When endometrioma is present, the stricture usually does not encircle the bowel completely, and the tumor can be lifted up from the wall of the bowel. The regional lymph nodes may be involved and enlarged if malignancy is present. However, the final decision may often rest with the pathologist after the tumor has been removed.

Thirty-eight cases of endometriosis of the sigmoid, rectosigmoid, and rectum in which the patients were encountered at The Mayo Clinic comprise the series under consideration. Five of these cases have been reported elsewhere; 1 by Mahle and MacCarty and 4 by Judd and Foulds. In 13 cases of this series, the lesions were situated in the sigmoid alone, while in 3 cases there were solitary endometriomas situated in the rectosigmoid. In the remainder of the cases, there was involvement of the various structures of the pelvis in addition to different portions of the lower part of the bowel. In many cases, the rectovaginal septum and the contiguous portion of bowel were involved. The ages of the patients represented in the series had a range approximating the menstrual life of the female, and extended from 25 to 54 years, the average being 38.1 years. Eighty-seven per cent of the patients represented in this group were between the ages of 30 and 49 years.

Pertinent data of this group are: 28 of the patients were married and 10 were unmarried. The total duration of the symptoms ranged from a low of 2 months to an extreme of 27 years. Twelve patients became pregnant; 23 had periodicity of symptoms. Eighteen patients had dysmenorrhea; 28 had abdominal pain; 20 had constipation; 3 had diarrhea; 11 had rectal pain; 11 had blood in the stools; and 6 had loss of weight.

The duration of endometriosis before the patient is seen by the physician often is much longer than that of carcinoma. The greater number of patients of this series said that they had experienced symptoms for from 2 to 5 years. As might be suspected, a sterility of relative stubbornness often is associated with endometriosis. The large number of patients in this series who became pregnant may be attributable to either one of two factors: (1) some of these patients had had their children before the onset of the disease, and (2) others had their lesions in isolated situations wherein there could be no interference with the reproductive organs. Six of the patients who complained of rectal pain had lesions in the rectovaginal septum. Loss of weight usually was associated with some disease other than endometriosis. Only 6 of the 38 patients reported such a reduction in weight.

Much reliance should be placed on an accurate, detailed history, because the physical findings of endometriosis of the sigmoid and rectosigmoid often are not of much help. Inspection and palpation of the pelvic region, however, will aid materially in diagnosis of lesions in the rectovaginal septum. Fixation of the pelvic organs may be noted on bimanual examination.

It should be noted that but 9 patients of the entire group showed a significant decrease in the concentration of hemoglobin in the blood. In this connection, it may be stated that some of the 9 patients had other pathological conditions to account for the loss of blood. It is interesting also that 2 patients had undergone colostomy for intestinal obstruction, 1 having had the operation 5 years, and the other 9 months, before coming to the clinic, where additional surgical treatment was provided.

Proctoscopic examination was performed for 18 patients and normal findings were reported for only 3 of these. Narrowing of the lumen of the bowel, projection of a mass into the bowel, or of a tumor outside the wall, were encountered in the remainder of the patients for whom proctoscopy was performed, except 1 patient in the examination of whom a definite carci-

noma of the rectum was visualized. Since there are no roentgenographic peculiarities for endometrioma of the bowel, the reports describing the condition of these patients stated either that the bowel was normal or that a stricture was present. Stricture, however, is not a characteristic filling defect. The differentiation between malignant and inflammatory conditions is extremely difficult at times in this region of the body.

It is also to be noted that some of the endometriomas in this series had not necessarily produced symptoms. A number were encountered and recognized during the course of pelvic operations for other diseases. When the lesion was recognized as an adenomyoma and was solitary, it was either untouched or removed, depending on the state of the bowel, the coexisting pathological condition in the remainder of the pelvic organs, and whether or not the ovaries were to be removed. When the endometrioma was not removed, a note was made that if subsequent difficulty should arise, recourse might be had to either roentgen-rays or radium therapy. In addition, other pathological changes in the bowel must be searched for as is illustrated by one patient who had an endometrioma in the sigmoid and a carcinoma of the rectum.

Thirty-one patients were treated conservatively and 7 radically. Treatment of the group as a whole was predominantly conservative and this trend has been rather definite in recent years. However, when radical intervention was deemed absolutely necessary, it was done. As has been pointed out, the diagnosis of endometriosis so often is in doubt up to and sometimes during surgical exploration that a definite rule as to the exact course of treatment cannot be laid down. When the lesion looks and feels like a malignant lesion, when metastasis cannot be found, and when evidence of the presence of endometriosis cannot be found in the pelvis, conservative resection of the bowel is the procedure of choice, especially if the patient is young and is desirous of having children. The desirability of preservation of the ability to conceive often may decide the course to be followed.

In the treatment of an older patient near the menopause concerning whom the question of future childbearing may be dismissed, roentgen-rays or radium implantations offer the possibility of the induction of an artificial menopause which will completely alleviate the symptoms and correct the existing pathologic condition. If obstruction exists, a temporary colonic stoma may be made and roentgen-ray or radium treatment may be given, in which an amount of irradiation sufficient to produce permanent inhibition of the ovarian function may be administered. This measure will remove cyclic stimulation of the ovarian hormones to the endometrium. Regression of the latter will then occur. However, conservative therapy, both in respect to preservation of the ovaries and operative procedure on the bowel, should be paramount.

Thirty-two patients in this series are living and well at the present writing. Four have lived 10 or more years since operation, 5 from 5 to 10 years, 16 from 1 to 4 years, and 7 for less than 1 year. There was but 1 death in the hospital for this entire series. The condition of patients was followed for varying lengths of time after they left the clinic and only 2 have been reported as having died. One of these patients was found at operation to have had carcinoma of the ovary in addition to endometrioma of the sigmoid and she died about 6 months after operation. The second of these patients underwent an operation elsewhere for an unknown condition and succumbed. The final condition of 3 patients could not be ascertained.

SUMMARY AND CONCLUSIONS

1. Eighty-seven per cent of the patients having endometriosis were between the ages of 30 and 49 years.
2. Symptoms attendant upon endometriosis usually are present for a longer period than those commonly associated with carcinoma or inflammatory conditions.
3. The patients are relatively sterile.
4. The presence of symptoms which are periodic in nature, such as constipation, diarrhea, rectal bleeding, or rectal pain, should suggest the presence of endometrioma.
5. Dysmenorrhea is often present.
6. Discomfort in the lower portion of the abdomen is a common complaint.

7. The general health of the patient is usually good.

8. Proctoscopic examination and roentgenographic investigation do not result in characteristic findings.

9. The diagnosis is always difficult and the symptoms vary considerably.

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LUDWIG'S ANGINA

ASHBEL C. WILLIAMS, M.D., Boston, Massachusetts

LUDWIG'S angina has been regarded as an entity by most authorities since Ludwig's classical description in 1836. Thomas, in 1908, reiterated this description and offered a practical surgical approach based on careful anatomical and pathological investigation. The mortality in Ludwig's 5 cases was 60 per cent. Thomas, in a series of 106 cases, reported a mortality of 40 per cent and prophesied a further reduction through better understanding and treatment of this type of infection.

But in a group of 31 recent cases, collected from several local hospitals (Table I), the mortality was 54 per cent. Such a rate, nearly as high as that reported by Ludwig a hundred years ago, suggests that knowledge of the advances made since his time is not general and that in most cases this disease still does not receive proper recognition and treatment.

In the American literature emphasis has been placed on the anatomy and the pathology of Ludwig's angina and, to some extent, on the surgical approach. The clinical aspects, which have received somewhat meager attention previously, will be stressed in this paper. A proved surgical approach will be described in detail. The rôle of tracheotomy, the choice of anesthesia and the use of certain drugs will be accorded the importance they deserve. The viewpoints presented have grown from clinical observation, a study of the 31 cases here mentioned, and a consideration of the literature.

This condition is not rare, 8 such patients having been admitted to the Boston City Hospital during the last 12 months.

ANATOMY

The clinical features peculiar to Ludwig's angina are due to an infection involving the tissues of both the submaxillary and sublingual spaces. Clinical manifestations of infection in both these regions are prerequisite to a diagnosis. Other spaces may or may not be involved. This conception is in agreement with Ludwig's description and with the consensus among those who have studied the disease since his time.

A thorough knowledge of the regional anatomy is essential to an adequate diagnostic and surgical approach. The key lies in the unyielding deep cervical fascia (Fig. 1). This fascia is fixed to the inferior border of the mandible from which it sweeps downward and inward to become attached to the hyoid bone, thus separating the suprahyoid region from the lower neck. Within the suprahyoid region, this fascia is attached to the anterior and posterior bellies of the digastric muscle, thus delimiting the submaxillary and submental areas (Fig. 1). The structure possibly second in importance is the mylohyoid diaphragm, formed by the two mylohyoid muscles which, from their attachments to the mandible, pass downward and inward to be inserted along the hyoid bone posteriorly while they fuse with one another anteriorly to form a median raphe (Fig. 2). Below the mylohyoid diaphragm anteriorly, and between it and the deep fascia, lies the triangular submental space, further bounded by the anterior bellies of the digastric muscles laterally and the hyoid bone inferiorly. Above the mylohyoid diaphragm lie the two sublingual spaces which are bounded laterally by the body of the mandible, above by the mucous membrane of the floor of the mouth and medially by a muscular raphe which is deficient anteriorly, allowing for communication of one sublingual space with its fellow of the opposite side (Figs. 2 and 4). The submaxillary gland lies at the posterior border of the mylohyoid muscle, resting partly in the submaxillary and partly in the sublingual spaces, permitting an avenue of communication between the two. The submaxillary space has potential communication, deep to the hyoid bone, with the lower neck (2). It also has potential communication with the parapharyngeal or lateral pharyngeal space by

From the Department of Surgery and the Mallory Institute of Pathology of the Boston City Hospital, Boston, Massachusetts.

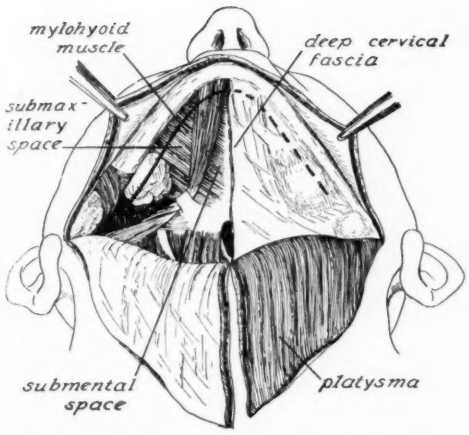

Fig. 1. Right, the skin and platysma have been reflected to show the deep fascia. Left, the skin, platysma, and deep fascia have been reflected to show the submaxillary and submental spaces. The solid line indicates the site of incision for unilateral infections. The dotted line indicates its extension in bilateral infections.

way of the stylohyoid sheath and the glossopharyngeal nerve (37).

The mylohyoid diaphragm prevents downward expansion of the sublingual space. The strong fascial attachments further close all these spaces from superficial expansion or communication.

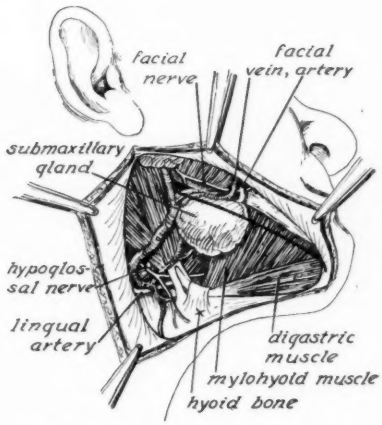

Fig. 3. The skin, platysma and deep fascia have been reflected. The relation of the incision to vital structures is shown. Only the facial vessels must be divided. The submaxillary gland may be reflected, incised or excised.

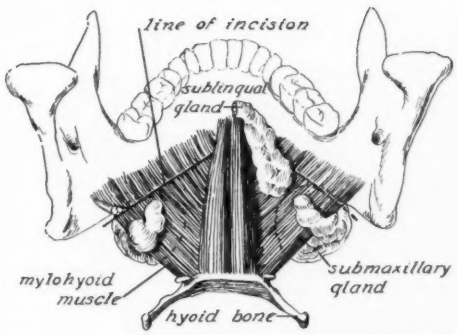

Fig. 2. The mylohyoid diaphragm as seen from above, indicating where it should be divided by incision from below. The sublingual spaces communicate about the anterior tip of the sublingual glands. Several structures have been omitted to allow visualization of the diaphragm. The sublingual gland is shown only on the right.

ETIOLOGY AND PATHOGENESIS

Streptococci, predominantly of the hemolytic group, are the causative organisms in most cases of Ludwig's angina, occurring alone, often with the staphylococcus or occasionally with the pneumococcus. Streptococci were present in 72 per cent of the cases in which culture reports were available. Others have reported a similar figure (4, 12, 31, 35). Staphylococci or pneumococci may be the only organisms noted. Recently (27, 28, 29) attention has been called to the frequence of secondary infection with anaerobic organisms

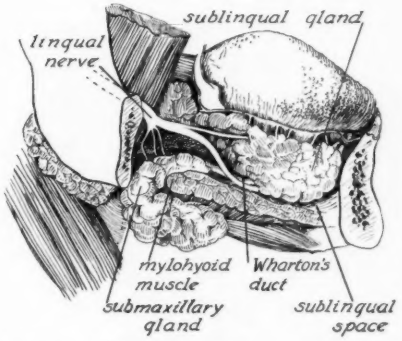

Fig. 4. The submaxillary gland lies at the posterior border of the mylohyoid muscle. The deep portion, with Wharton's duct, extends into the sublingual space while the bulk of the gland lies more superficial in the submaxillary space. The tongue and mucous membrane of the floor of the mouth are evident.

TABLE I.—SUMMARY OF 31 CASES

Patient, age	Hospital†	Culture report	Anesthesia	Tracheotomy	Sulfanilamide administered	Spontaneous drainage	Result
M.L., 53	M.G.H.	Streptococcus hemolyticus, Staphylococcus albus	Novocain	Pre-operative	+		Died
T.M., 30	M.G.H.	Streptococcus hemolyticus	No surgery	None	+	+	Recovered
T.D., 34	M.G.H.	Hemolytic staphylococcus	No surgery	None		+	Recovered
M.P., 46	M.G.H.	*	Ether	During operation			Died
E.M., *	M.G.H.	*	*	None		+	Recovered
M.M., 53	M.G.H.	Staphylococcus	*	Postoperative			Died
A.D., 15	M.G.H.	*	Novocain, N_2O	None			Recovered
L.G., 43	M.G.H.	Streptococcus hemolyticus	Evipal	None			Recovered
E.S., 26	P.B.B.H.	Non-hemolytic streptococcus	Avertin	None			Died
E.S., 35	M.H.	Pneumococcus XIX	N_2O, O_2	During operation			Died
D.D., 66	M.H.	*	Evipal	None	+		Died
W.R., 76	B.C.H.	Streptococcus hemolyticus, Streptococcus viridans, Staphylococcus aureus	Cyclopropane	During operation	+		Died
M.M., 65	B.C.H.	*	No surgery	None	.	+	Recovered
M.M., 11	B.C.H.	Streptococcus hemolyticus	*	None			Died
W.S., 23	B.C.H.	*	Cyclopropane	None	+		Recovered
M.G., 59	B.C.H.	Streptococcus viridans, Micrococcus catarrhalis	N_2O, O_2	None			Recovered
G.B., 56	B.C.H.	Streptococococcus hemolyticus	Pentothal	None	+		Died
V.A., 55	B.C.H.	Staphylococcus albus, Pneumococcus VIII	N_2O, O_2	During operation			Recovered
M.P., 48	B.C.H.	*	No surgery	None			Died
T.F., 47	B.C.H.	*	Ether	None	+		Died
R.V., 26	B.C.H.	*	N_2O, O_2	Postoperative			Died
N.B., 46	B.C.H.	Streptococcus hemolyticus, Staphylococcus aureus	Novocain	None			Died
Z.L., 53	B.C.H.	Staphylococcus albus	*	None			Recovered
J.L., 28	B.C.H.	Streptococcus hemolyticus, Staphylococcus albus, Staphylococcus aureus, Vincent's	N_2O, O_2	None		+	Recovered
C.H., 24	B.C.H.	Staphylococcus albus, Streptococcus viridans	Pentothal	None		+	Recovered
J.C., 21	B.C.H.	*	N_2O, O_2	None	+		Recovered
L.B., 62	B.C.H.	*	N_2O, O_2	None			Died
S.C., 25	B.C.H.	*	N_2O, O_2	Attempted**			Died
J.C., 51	B.C.H.	*	Cyclopropane	None	+		Died
W.M.,26	B.C.H.	Streptococcus hemolyticus	Pentothal	During operation	+		Recovered
W.R., 49	N.H.	Non-hemolytic streptococcus	Pentothal	None			Died

*Information lacking
**Died of asphyxia under anesthesia

†M.G.H.—Massachusetts General Hospital
P.B.B.H.—Peter Bent Brigham Hospital
M.H.—Malden Hospital
B.C.H.—Boston City Hospital
N.H.—Newton Hospital

and to the synergistic effect they exert. Spirochetes, spirilla, fusiform bacilli, anaerobic streptococci and Clostridium welchii are often present. Too commonly anaerobes are not sought for by special methods and are consequently not reported.

The portal of entry of infection may be a lesion anywhere about the lower lip, tongue, floor of the mouth, gums and teeth of the lower jaw, tonsils or pharynx (35). Calculi in the submaxillary gland or duct have been mentioned as a cause (6). Infections incurred about the lower molars, particularly following extractions, are the common source, constituting the initial episode in 51 per cent of the cases of this series. This has also been the experience of others (2, 12, 15, 32, 33).

The manner of development of the infection has been the subject of several investigations (2, 16, 35, 37). Whether the spread is via lymphatics or by contiguity of tissues matters little. However, it is of practical importance to recognize that, regardless of whether the submaxillary or sublingual space is first involved, since one communicates with the other, both will shortly partake in the process. The resulting pathological picture is that of a diffuse, edematous, and rapidly spreading cellulitis beneath the deep cervical fascia and involving these two spaces.

Pus in considerable quantities is a late development. When the swelling is incised, one encounters only a porky edema with perhaps a streak of thin watery pus here and there. Because pus is scanty and lies beneath the deep fascia, fluctuation should not be expected. It was absent in 94 per cent of the cases in this series.

Due to the restraining deep cervical fascia and mylohyoid muscles, expansion of the submaxillary and sublingual tissues is upward and posterior at the expense of the oral and pharyngeal cavities. This swelling often assumes literally immense proportions. The tension thus created by a fulminating infection so confined accounts in part for the necrosis of the deep tissues noted so constantly at necropsy. The impingement on surrounding structures which results gives rise to dysphagia, dysphonia, and respiratory embarrassment.

Spontaneous rupture into the mouth or throat occurs, having taken place in 19 per cent, or 6 cases, of this series. All of these patients recovered, though 2 required operative drainage as well. This eventuality is not favorably stressed since delay, with the hope for some such happy outcome, only tends to minimize the chance of successful intervention. It should be remembered that in 81 per cent of the cases spontaneous rupture did not occur.

CLINICAL FEATURES AND DIAGNOSIS

Ludwig's angina has certain clinical characteristics. A massive swelling, often bilateral, always brawny and tender but rarely fluctuant, involves the suprahyoid region, being extreme in the submaxillary area. The overlying skin is conspicuously free of inflammation, showing only edema. Such external manifestations are an indication of infection in the submaxillary and probably in the submental space.

The floor of the mouth is raised, edematous, and brawny. The mucous membrane beneath the tongue is often ulcerated and dirty grayish white. The tongue is swollen, pushed upward, and may become so crowded by sublingual edema that, filling the available space in the mouth and pharynx, it is forced forward as well, its tip even protruding between the teeth anteriorly. The presence of these signs in the oral cavity is diagnostic of infection in the sublingual space. The patient experiences pain and difficulty on attempting to open his mouth. Deglutition and speech are trying and often impossible. As a rule, respiratory embarrassment is present, a vital feature, easily and often overlooked. Temperature, pulse, and respirations vary in this condition but usually all are moderately elevated.

It is felt that a case must follow the above description rather closely to permit a diagnosis of Ludwig's angina.

COMPLICATIONS

Most imminent, most rapid, and most insidious of the complications is respiratory obstruction which may be due to blockage of the airways by an elevated or edematous tongue. Or it may occur in the larynx, precipitated by

laryngeal edema (35). Irritable anesthetics introduce an element of spasm which may suddenly make a partial obstruction complete. Of the patients in this study, 80 per cent had varying degrees of respiratory difficulty. Emergency tracheotomy was performed in 8 instances. Four patients on whom tracheotomy was not done died of asphyxia.

Bronchopneumonia complicated 25 per cent, or 8 cases, in this series, 7 of which terminated fatally. It was a late complication, the time of development averaging 8 days after the onset of the infection in the neck. Surgical drainage had been instituted in 7 of these patients but in every instance seems to have been too conservative so that an undrained focus remained. Such lingering infections invite pneumonia, which is shortly fatal though the suprahyoid infection may be clearing. Tracheotomy probably aids in preventing this complication. Certainly it plays a minor rôle as a cause, having been performed in only 3 of the patients who developed pneumonia.

Further spread of infection is dangerously common, having occurred in 25 per cent, or 8 cases. In 7 of these, surgery was delayed or conservative. Guided and confined by the deep cervical fascia, sepsis has several possible routes of extension. The process may invade the submental space. It may burrow downward, deep to the hyoid bone, into the lower neck to find its way along the carotid sheath and eventually into the anterior mediastinum (2). Or it may extend posteriorly, probably along the stylohyoid sheath, into the parapharyngeal space possibly to involve the larynx (35, 37). Of the 8 cases in which extension took place, 7 were fatal.

Septicemia is less common but highly fatal. From 2 patients positive hemolytic streptococcus blood cultures were obtained. These patients died.

At necropsy, Ludwig noted widespread suppurative gangrene of the tissues deep to the deep cervical fascia. He observed this process extending into the mediastinum and remarked on the presence of pneumonia. These patients had survived 10 to 12 days. A similar process, involving the deep spaces of the upper and lower neck was revealed at necropsy in 2 cases of the present series. In one of these the mediastinum was invaded and there was bronchopneumonia. In both these cases surgery had been deferred until suppuration should appear. In a third case, in addition to bilateral bronchopneumonia, suppurative necrosis, chiefly about the base of the tongue, was noted. A short, transverse, submental incision obviously had been incompetent in view of the location and extent of the infection present.

TREATMENT

The aims of treatment are to establish an airway, to relieve tension, to secure drainage, and to combat the infection through supplementary measures.

The most dependable means of securing an adequate airway is to perform tracheotomy. It has a negligible bearing on the occurrence of pneumonia. Since the tracheotomy incision is made below the cricoid cartilage, away from the infected field, it does not increase the danger of spread of infection. Five emergency tracheotomies were performed for acute respiratory obstruction with onset during anesthesia for operative procedures on the neck. These patients became spastic, or gasped, became deeply cyanotic, and stopped breathing, leaving no doubt that immediate tracheotomy was essential.

However, indications are not so dramatic when obstruction develops on the ward. Its onset is insidious and is heralded by an elevation of the pitch and timbre of the sounds which may be described as crowing. Too great emphasis cannot be placed upon this diagnostic point which has recently been stressed by Cawthorne. Increase in rate and decrease in depth of respirations is noticeable. The use of the voluntary muscles of respiration and retraction of the intercostal spaces with inspiration are valuable signs. A mild, dusky cyanosis may be present but is by no means essential. These signs are indications for tracheotomy. The surgeon should not wait for the patient to complain of difficulty in breathing or for such signs as gagging or deep cyanosis. For these are more than indications for tracheotomy, they are forebodings of sudden death.

A tracheotomy kit should be kept beside the patient at all times and a careful liaison be maintained between the ward and the surgeon to cover the necessity for prompt tracheotomy should the occasion arise. The latter should be done under local anesthesia.

At time of operation, if the patient reveals any signs of respiratory difficulty, the trachea may be exposed and this wound packed with vaseline gauze before the infected areas are incised. Then, if necessity arises, completing the tracheotomy requires only a moment.

When a case fulfils the criteria prerequisite to a diagnosis of Ludwig's angina, immediate surgical drainage is indicated. It is too common a viewpoint that localization and fluctuation should be awaited and regarded as indications for surgery. Fluctuation and pus will develop in about 50 per cent of the cases but only after a matter of days. While one waits, he is exposing his patient to the grave complications here mentioned.

Davis, writing on Ludwig's angina in 1906, emphasized the necessity for "fearless surgery." Since that date, Thomas, Leonardo, Van Wagenen and Costello, Colp, and Bailey (3) have echoed this point of view, advising surgical drainage according to or closely resembling the following procedure.

The incision should commence just below and slightly anterior to the angle of the jaw and run forward, parallel to and about 1 centimeter below the body of the mandible, until it reaches the midline anteriorly (Fig. 5). If the infection is bilateral, the incision should extend continuously around to a similar point near the angle of the jaw on the opposite side, always close to the mandible. It should divide the deep cervical fascia, the mylohyoid diaphragm, and the anterior belly of the digastric muscle (Fig. 1) penetrating upward to a depth that will allow an exploring finger to reach the base of the tongue and the mucous membrane of the floor of the mouth. Such an incision lays open the sublingual, submaxillary, and submental spaces. Equally important, it cuts the restraining fascia and mylohyoid diaphragm (Fig. 2), allowing the tongue and edematous tissues above to descend, thus lessening tension and vastly improving the airway. This approach should

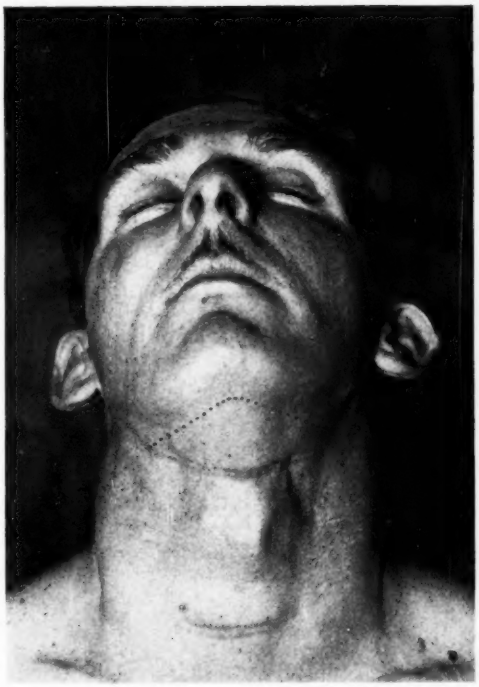

Fig. 5. Showing a scar 1 year after operation. A bilateral continuous incision was made and tracheotomy prepared for but not performed. The dotted line indicates the preferable site of incision.

give immediately noticeable and increasingly apparent respiratory relief.

The wound should be left open and packed with iodoform gauze which is left in place from 12 to 24 hours. At the end of this interval all hemorrhagic oozing should have stopped. The pack should then be removed and warm wet dressings applied.

Bailey has used this incision in 4 cases during the past 2 years with no fatalities (5). In addition, he removed the submaxillary gland in 2 of these patients, a procedure which had previously been recommended by Colp and by Ramsdell and which greatly increases the exposure of the deeper tissues, facilitating drainage. This measure was not carried out in any of the 31 cases in the present series.

There are no important nerves along the course of the incision described and the only

large vessels which are encountered are the facial artery and vein. These are easily located as they wind up the lateral aspect of the posterior portion of the submaxillary gland and over the mandible (Fig. 3). These vessels should be isolated, ligated, and cut. The lingual nerve is deep to the mylohyoid muscle and near the midline so it need not be feared. The hypoglossal nerve and lingual vessels are safely below, running along posterior to, and a trifle above, the hyoid bone. The carotid sheath is far posterior and below. A branch of the facial nerve loops down lateral to the mandible emerging in front of the parotid gland but it does not extend below the mandible and therefore is out of the operative field. Any injury to the salivary glands and muscular structures is inconsequential.

Mosher, writing on infections of the neck, states that "cosmetic surgery and life-and-death surgery do not mix"; a sound observation. However, the cosmetic results following the incision described are surprisingly good, the scar being noticeable only when the head is thrown back (Fig. 5). Healing is rapid and the functional result satisfactory.

Mosher advocates a T-shaped incision over the submaxillary area as the ideal approach to all infections of the deep fascial spaces of the neck. Such an incision affords excellent exposure to all these spaces but seems chiefly applicable to infections which have invaded the posterior or lower spaces.

The choice of anesthesia warrants deliberation. Most writers have advised the use of local anesthesia (2, 11, 35, 37). However, it has several disadvantages. Several writers (4) have observed that local infiltration sufficed for the superficial part of the operation but that some form of general anesthesia was essential when the deeper structures were incised. The patient was thus exposed to the hazards of two anesthetics. According to Tovell, to secure anesthesia for submental and submaxillary operations, the usual neck block must be supplemented by the deep injection of 20 to 30 cubic centimers of novocain into the operative site. Many surgeons feel that the injection of an anesthetic into infected tissues fosters the progress of infection. Such an objection seems especially well founded in Ludwig's angina since one of th chief aims of treatment here is to decreas tension due to an edematous process. On th other hand, local anesthesia has distinct ad vantages which are well known. Should it b selected for use, pentobarbital sodium, 1.5 t 3 grains, by mouth is suggested as pre-opera tive medication to forestall any possible re action to novocain.

With few exceptions (12, 15) writers on Ludwig's angina have warned against the us of nitrous oxide and ether because of the high incidence of spastic respiratory obstruction or because they felt that these patients often could not survive general anesthesia. Of 11 patients to whom these agents were administered, 3 had to be subjected to emergency tracheotomy during operation. A fourth died while tracheotomy was being performed. Cyclopropane was administered to 3 patients, 1 of whom had to have an emergency tracheotomy because of obstruction, while a second showed signs of spastic obstruction which were visibly relieved by incision and drainage. Such experiences lend weight to the previous admonitions regarding inhalation anesthetics.

In the hands of some, endotracheal intubation (26, 34) might allow for exceptions to this statement. However, at the Boston City Hospital, it has been found that intubation is often difficult or impossible because of distortion of the airway. Helium (7, 13) greatly extends the range of usefulness of inhalation anesthesia in cases of partial respiratory obstruction but it is not yet available in most hospitals.

The intravenous anesthetic agents (24), evipal soluble and pentothal sodium (9, 19) offer great advantages. They are of brief but controlled duration, the patient recovering rapidly and without the ill effects often following ether. Most important of all, they seldom produce spastic blockage of the airways which attribute immediately enhances their desirability in Ludwig's angina. Also, the anesthetist is out of the surgeon's way. However, their disadvantage, which has led to repeated warnings (9, 19, 24) against their employment in such infections of the neck, is their property of depressing the respiratory center. No reports of their actual use in any series of such

cases is available in the American literature, however.

Through the efforts of several anesthetists connected with the Boston City Hospital, pentothal was used in 4 and evipal in 2 cases of Ludwig's angina in this series. Two patients stopped breathing during the administration of pentothal but both survived. In one of these, respirations began after the injection of 1 ampul of metrazol and a brief interval of artificial respiration. Tracheotomy was required in the second patient who was under light anesthesia and went into spasm, partly voluntary, during the operative procedure. The diagnosis of Ludwig's angina was recognized only after operation so that the lack of preparation for the treatment of operative complications was nearly fatal. The operative course of the 4 remaining patients was uneventful.

Bailey (3), who strongly recommends evipan (evipal) for Ludwig's angina, has used this agent in his last 4 cases without any untoward respiratory complications (5). He uses the operative approach advocated here.

These experiences in anesthesia seem to indicate that intravenous barbiturates are the safest choice in this condition which is, at best, fraught with danger. Pentothal sodium is preferred. This is offered as a suggestion which future experience may or may not substantiate.

Its use must be restricted to those familiar with the administration of pentothal. Lundy (25) suggests that, if pentothal is used, a 2.5 per cent solution would be best and he recommends that oxygen be administered throughout the procedure. Atropine, 1/100 grain, should be administered before operation. Coramine, 3 cubic centimeters, should be mixed and injected with the barbiturate as a prophylactic against respiratory depression. Artificial respiration and repeated intravenous injections of metrazol, 2 cubic centimeters, or picrotoxin, 3 milligrams (8), are indicated in event of serious respiratory depression. The jaw must be supported, and preparation for emergency tracheotomy is essential. Even should respiratory cessation occur with pentothal, prompt emergency treatment gives a good prognosis.

Recent animal experiments reported by Weese, suggest that intravenous barbiturates may cause respiratory cessation in cases of sublingual phlegmon through an abnormal carotid sinus mechanism. He advises waiting 5 minutes after the induction before operating as such an interval would abolish this danger.

As an adjunct to surgery, sulfanilamide deserves first consideration. Since the causative organism in about 64 per cent of the cases was the hemolytic streptococcus alone or with some other organism sulfanilamide is indicated in over half of these cases. It should be a rule to culture the wound, the floor of the mouth, or any related lesion in every case and to administer sulfanilamide only in cases yielding hemolytic streptococcus cultures, for its possible ill effects are not to be courted unnecessarily.

Sulfanilamide was administered in 10 cases but in only 2 of these was its administration accurate and the organism proved to be a hemolytic streptococcus. In 1 case spontaneous drainage near the base of the tongue occurred. Operation and tracheotomy were necessary in the other. Both recovered. Of the 8 remaining patients, several obviously benefited but sketchy administration of the drug or failure to take cultures prevents accurate reporting of these results.

Difficulty in swallowing often renders impossible the oral administration of sulfanilamide. Where the drug is indicated it should be given in maximum dosages (21) regardless, using prontosil or sulfanilamide in solution (21) by hypodermoclysis if necessary, a perfectly satisfactory route of administration. Best results will be obtained if the drug is continued until healing is well advanced (20).

Finally, let it be clear, that in these severe infections, sulfanilamide is not advocated alone but only as an adjunct to surgical treatment. Temporizing at this stage is an unjustified assumption of responsibility.

In a recent editorial (1), it was stated that, because of its sulphur content, pentothal sodium should not be administered to patients under treatment with sulfanilamide. However, according to Long (22), this statement is based on theory and is not borne out by clinical experience.

Moist heat, applied locally both before and after operation is beneficial. A dressing impregnated with warm normal saline or Dakin's solution, gently packed into the wound and supported generously by flaxseed poultice serves excellently. This should be changed every 2 hours.

Homans makes the following statement with reference to the use of cold: "Therefore it is almost inconceivable that it (cold) should have a favorable local action upon inflammatory conditions in which local heat and hyperemia are purposeful and useful physiologic responses." This statement is heartily concurred with, and the use of cold applications in Ludwig's angina decried.

In view of the work of Meleney (27, 28, 29) and others, it is probable that anaerobes are a potent factor in the virulence of these infections and that they are not recorded because usually only aerobic cultures are employed. Anaerobic cultures in such cases should be routine. Meleney (28) urges prompt and radical surgery that the tissues may be effectively oxygenated. In gangrenous or slowly healing wounds yielding positive anaerobic cultures, hydrogen peroxide irrigations (14) and zinc peroxide dressings (27, 28, 29) are definitely indicated. Dramatic improvement in the local and general condition will follow their use.

Parenteral fluids are often required since the oral intake may be interfered with through difficulty in swallowing.

SUMMARY AND CONCLUSIONS

Ludwig's angina is an infection involving the tissues of the submaxillary and sublingual regions and is characterized by a nonfluctuant, brawny edema in these areas. Gross pus may appear late. Immediate surgical relief is indicated once the diagnosis is made. The deep cervical fascia and mylohyoid muscles must be widely incised. Pentothal sodium is recommended as a satisfactory anesthetic provided one has a thorough knowledge of its use. Tracheotomy is often life saving. Its indications may be overlooked. The streptococcus alone or with other organisms occurs in 72 per cent of the cases. Anaerobic organisms are often present. Sulfanilamide is of great value in cases with positive streptococcus hemolyticus cultures. Zinc peroxide is indicated when anaerobic organisms are present. The chief complications are respiratory obstruction, pneumonia, extension of sepsis and septicemia. All give a grave prognosis.

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THE FORMATION OF GANGLIA AND CYSTS OF THE MENISCI OF THE KNEE

Observations on the Golgi Apparatus

E. S. J. KING, M.D., M.S., D.Sc., F.R.C.S., F.R.A.C.S., Melbourne, Australia

THE methods of histological investigation which are usually applied to tissues removed at operation are the routine forms of staining and such others, in special cases, as can be applied to material kept in the ordinary and commonly used fixatives.

Although, in the face of a number of well known false prophecies that certain fields had been "well-reaped," another such statement may be ill advised, it seems probable that there is little further to be discovered in commonly observed pathological conditions by the use of present apparatus and ordinary staining methods. That this is generally thought of normal tissues is shown by the increasing use of new methods by histologists. Techniques, however, which are relatively simple in a laboratory where material may be obtained at will and at suitable times, become irksome and tedious, if not difficult, when applied to human tissues obtained at operation. Nevertheless such special methods of study must be applied to pathological conditions if advances are to be made in pathological histology. The advantages of their introduction have been abundantly demonstrated in the case of brain tumors. Not only do the results throw light on the pathological condition but often the abnormal conditions suggest explanations of normally occurring phenomena.

For some time the writer has put aside part of tissues removed from operation cases for special study and in appropriate cases for investigation of the Golgi apparatus. Despite the statement that the Golgi apparatus of the cells of synovial membrane had not been observed (10), this structure was found to be demonstrable readily in human tissues. This observation has been recorded (9).

From the Out Patient Service, Royal Melbourne Hospital.

The method used was Da Fano's cobalt nitrate-silver impregnation technique. In this method early fixation in the cobalt nitrate formalin mixture is essential. I have been able to obtain fair and even good results with thyroid gland and other tissues when fixation had been delayed for 2 and, in cold weather, 3 hours. With synovial membrane cells, however, results can be obtained, in my experience, only after immediate fixation. The best preparations are obtained when the material is dropped into the fixative on the operating table.

The observations made on the Golgi apparatus of the cells in ganglia and cysts of the semilunar cartilages of the knee seemed to throw light on some of the problems of their development and therefore are discussed here.

HISTOLOGICAL CHARACTERISTICS

In the earliest stage of formation of ganglia there is a proliferation of cells in the wall of the joint or tendon sheath. These cells, at the same time, become spheroidal in shape and swollen and thus much larger than their neighbors. The abundant protoplasm contains vacuoles which, like those of ordinary synovial cells, contain material not easily stained. A mucinoid material also collects between the cells and separates them from each other.

These areas—there are multiple foci of cell activity—gradually enlarge both by involvement of other cells at the periphery and by increase in the amount of intercellular material in the region. Gradually so much material accumulates that relatively few or even no cells are to be found in the middle of the affected zone.

These various foci may coalesce and so, if the ganglion be examined at an early stage, it may be multicystic but at a late stage it

may show, unless the process is progressing at the periphery, but very few cavities or only one, perhaps irregular, cyst.

The changes occurring in cysts of the menisci of the knee are strictly comparable with those seen in ganglia. Minor differences need not be discussed here.

The walls of the final cyst or cysts are lined with a modified connective tissue which is like that forming typical synovial membrane. It is assumed that the evidence for the connective tissue nature of the synovial lining is appreciated. A review of the literature or a study of sections of this tissue leaves no doubt concerning its morphology. Mention is made of it since some recent articles refer still to "endothelial" linings.

The sequence of events then is that, in certain areas, cells become enlarged and at the same time there is an accumulation of mucinoid material. When the active stimulus discontinues, the process ceases and the cells at the periphery become, or those which have been but slightly affected remain, spindle in form and the central material is thus surrounded by tissue which is of the synovial type.

The problem in the interpretation of these observations is whether the process is a degeneration or is the result of a remarkable cellular activity and secretion.

In order to decide this question the best criterion seemed to be the character of the cells which were found in the "degenerating" areas. Since the state of the protoplasm in minor degrees of change is not easy to determine, recourse was had to the cytological "organoids" which are known to be affected rapidly by adverse influences.

THE GOLGI APPARATUS

The Golgi apparatus of cells of synovial tissue has been more readily demonstrable in abnormal than in normal conditions. This is true even in cases in which the reticular material is not apparently greater in amount. Some experiments suggested that this was due to differences in hydrogen-ion concentration. However, in so far as the fixing solution is an un-buffered slightly acid solution, it is probably due to some more subtle factor.

Whatever may be the cause of differences in impregnation, care must be taken in making comparisons between the large cells of the ganglia and normal cells. Such comparisons should be made between the large cells and such others in the same section which are by ordinary histological criteria "normal." This also overcomes the difficulty of comparisons between tissues in which silver impregnation may be slightly different.

The Golgi apparatus of ordinary synovial cells is, in sections, a reticular structure varying somewhat in size and shape and also in its position in the cell; in general, it resembles that of a connective tissue cell but is decidedly more developed and prominent. When the cells are altered, as e.g. in mild forms of inflammation, the Golgi material is greater in amount and still more prominent. This prominence is apparently associated with a larger amount of secretion since it is most obvious in the larger (more voluminous) cells and in those nearer the surface; in addition the apparatus is related in position to vacuoles in the cells.

In ganglia extraordinary changes are to be observed. The cells which become swollen contain an extremely complex Golgi apparatus. It is difficult to obtain a complete idea of the structure of the apparatus in thin sections since only part of it is seen (the larger cells are 30μ, or even larger, in diameter) and in thick sections the superimposed portions cannot be seen and disentangled readily. Observations were made therefore on both thin serial sections and medium sections.

In the affected areas, the Golgi apparatus of even the smaller cells becomes considerably enlarged and occupies a large part of the cell protoplasm. As well as occupying the main portion of the cell as it does in the resting state, it extends into the protoplasmic processes. This results in gross irregularities of contour.

In some of the cells the Golgi apparatus increases in amount *pari passu* with the cellular enlargement, but in many, especially the largest cells, the amount of Golgi material appears to be disproportionately large. The principal portion of the material adopts a peripheral position, though processes may

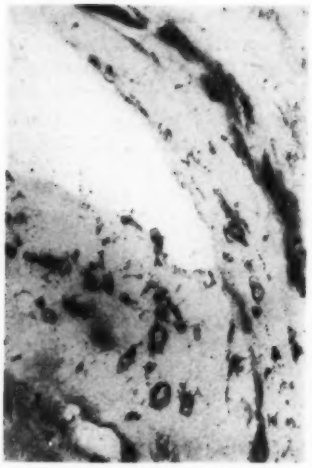

Fig. 1

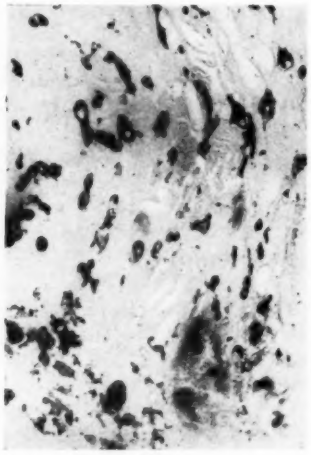

Fig. 2

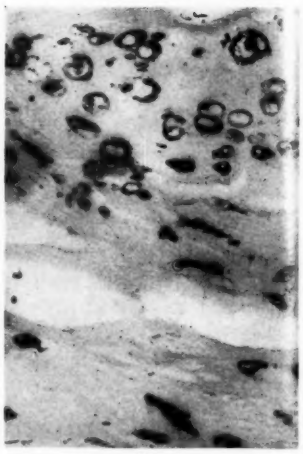

Fig. 3

Fig. 1. Photomicrograph of portion of the wall of a cyst of the meniscus showing the greatly enlarged cells containing a hypertrophied Golgi apparatus. The intercellular mucinous material is shown. The clear space is artefact. ×264

Fig. 2. Photomicrograph of portion of the contents of a cyst of the meniscus showing large cells with hypertrophied Golgi apparatus. ×264

Fig. 3. Photomicrograph similar to that shown in Figure 2, showing large cells. The peripherally distributed Golgi apparatus is shown cut in section. The nuclei are not apparent. (See Fig. 11.) ×264

pass into the central area of the cell especially to and around vacuoles. In many cases this appearance, which is very characteristic of some sections (Figs. 3, 9, and 10) seems to be due to shrinkage of the protoplasm toward the boundary of the cell and thus gives rise to eccentric condensation of the reticular material. In other cases, however, there is but little evidence of shrinkage and the peripheral position may be regarded as actual.

In a microscopic section, this structure is cut across so that it appears in more than one section. If the middle section is shown, the Golgi apparatus appears as a ring which is, in places, more or less thickened (Figs. 3 and 10). If either the proximal or distal part is shown then the apparatus appears as a network (Fig. 9).

At first sight these structures give the appearance of irregularly impregnated nuclei and in unstained sections were at first regarded as such. However, when sections are stained (with alum-carmine, hematoxylin, etc.) the nucleus is readily recognizable lying within the cavity of the Golgi ring. Incidentally the photomicrographs illustrating the morphology of the apparatus were made from sections lightly stained, so that the reticular material should not be overshadowed by other features. The nuclei therefore are not displayed clearly (Figs. 8 and 10). In stained sections also protoplasm can be discerned in the middle part of most cells, so that the explanation of an artefact nature of the ring appearance can only be partly true.

An appearance similar to this though less well developed is to be seen at times in cells of normal synovial membrane. At first I was content to regard it purely an artefact, but though it may be due partly to imperfect impregnation, the observations made on cells in ganglia suggest that it is a type of structure which it is necessary to recognize.

The typical entire structure is a more or less complete basket which surrounds the nucleus and the vacuoles in the protoplasm. It is composed of an irregularly undulated sheet which, in most cases, shows numerous fenestrations of varying shape and size. This gives a lattice-work appearance which may be irregular but at times is remarkably regular in structure.

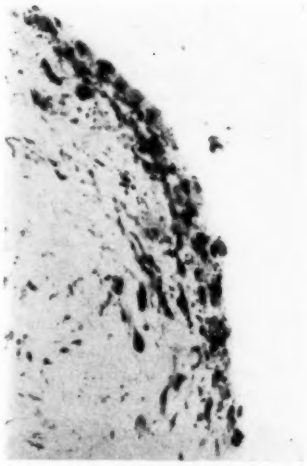

Fig. 4

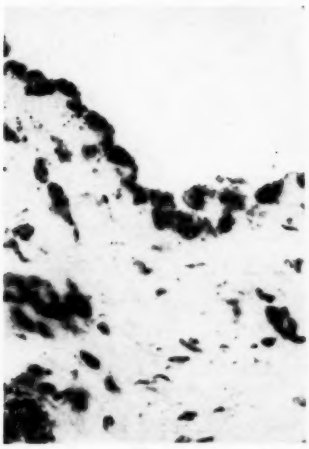

Fig. 5

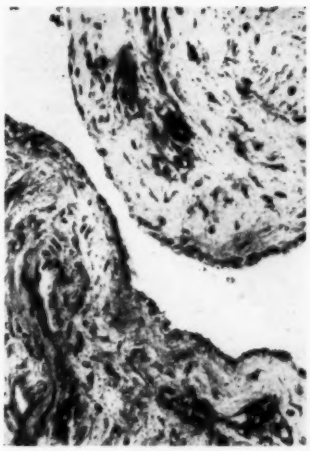

Fig. 6

Fig. 4. Photomicrograph of portion of wall of ganglion showing typical "synovial" lining. The deeply stained Golgi apparatus and the lighter nuclei may be seen in some cells. ×350

Fig. 5. Photomicrograph of the wall of a cyst of the meniscus showing the Golgi apparatus of the cells. The nuclei are recognizable as more lightly stained structures. ×396

Fig. 6. Photomicrograph of portion of a cyst of the meniscus. The synovial lining is one cell thick and resembles endothelium. ×264

Although in many cells the basket is complete and in others incompleteness seems to be due to mechanical removal of portion of the structure during the preparation of the section, in other examples the basket seems to be genuinely incomplete or only partially developed. Whether the hiatus be regarded as a large fenestration or as imperfect development of the reticular material is probably immaterial in the present state of knowledge.

Between the typical cells and lying in the mucoid material there are small anuclear pieces of protoplasm which contain a certain amount of Golgi material. This is still well impregnated with silver and seems to be comparable with material observed in desquamated cells in actively secreting states elsewhere. In some of these the Golgi material is reduced to a number of granules instead of the usual network. This is the exception rather than the rule, however; usually as the protoplasm disintegrates the Golgi material disappears.

In the later stages, when the active process has subsided, the tissue lining the cyst shows cells, whose Golgi apparatus is closely similar to ordinary synovial cells, i.e., it is a reticular mass about the size of the nucleus and occupying the main area of the protoplasm (Figs. 4 to 6).

ANALYSIS OF STUDY

The study of tissues by any new—or previously unused—method of examination opens up avenues of approach to various problems, but at the same time results obtained by such methods require careful interpretation and may, in themselves, add further complications.

The material described here may be considered therefore from two points of view: (a) in so far as it gives further information concerning the characteristics of the Golgi apparatus of cells in general and (b) as it helps to elucidate the questions of pathology.

a, The Golgi apparatus is a special part of the protoplasm of tissue cells, both animal and plant, which is demonstrated by staining by osmic acid or impregnation with silver. It appears to be fluid and lipoidal in nature. Not only has it been demonstrated in almost all cells but has been observed in unstained cells, so that there seems little doubt as to its actual

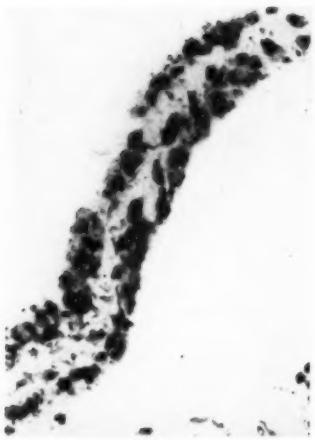

Fig. 7

Fig. 8

Fig. 9

Fig. 7. Photomicrograph of the walls of adjacent cysts of the meniscus. ×396

Fig. 8. Photomicrograph very similar to that shown in Figure 7. The lightly stained nuclei and the deeply impregnated Golgi apparatus are clearly demonstrated. ×300

Fig. 9. Photomicrograph of a group of cells showing the "basket" character of the Golgi apparatus in enlarged synovial cells. ×295

existence, i.e., it is not an artefact. It has been shown to be associated closely with the production of secretion products by so many observers that a relationship between it and the formation of secretion is now definite. The way in which it forms or modifies secretion granules is still uncertain, but it is not necessary to discuss such details here.

When a cell becomes active and secretion occurs, the Golgi apparatus becomes hypertrophied, sometimes greatly so; and with cessation of secretion it again becomes smaller. Different kinds of change have been observed in different cells, in these circumstances, but increase in the amount of the Golgi material is invariable. Sometimes there is dissemination to and occupation of all parts of the protoplasm.

Fig. 10. Photomicrograph similar to that shown in Fig. 9; some of the cells are shown only in middle zone. ×295

In the examples described here there is an extraordinary hypertrophy of the Golgi material. In thick sections the "basket" character of the material is very readily seen. Such forms have been described in other cells (3), but I have not observed any cells or seen illustrations which show this feature so well as do the large cells in the walls of developing ganglia.

Another morphological feature of the apparatus described by Hirschler and Bowen is its essentially lamellar structure. Bowen considered that the characteristic reticular appearance is what would be seen on optical section of curved plates. I have been unable to satisfy myself that this is so for some cells, but in others there is no doubt of the lamellar architecture. This is well shown in some of the large cells in developing cysts of the menisci and ganglia. In some cases the lamellæ are unbroken but usually there are openings o

varying size and shape in the plates giving an irregular lattice-work appearance.

Secretory granules were not demonstrated but the vacuoles were closely associated with portions of the Golgi apparatus, usually surrounded completely or in part by the impregnated material.

In these conditions therefore, when the Golgi apparatus is an extremely well developed and robust body, it is easy to determine the general features of its structure.

b, Relatively few observations have been made on the changes occurring in the Golgi material in pathological conditions. Disintegration of the apparatus has been shown to occur when cells undergo degeneration and autolysis. This is well shown in degenerative areas in tumors and is reflected in the necessity for early fixation of tissue for the demonstration of the structure. It was sensitiveness of the Golgi material to adverse influences that suggested that the condition of it in ganglia might throw some light on the nature of the processes occurring.

Various hypotheses have been put forward to account for the development of these cysts. In previous papers the writer has shown that the cysts both in ganglia (8) and in the menisci (7) come to be lined by a connective tissue which is like synovial membrane. Others have confirmed this, hence the hypotheses depending on the supposition that they are lined with endothelium need not be considered.

Several writers however refer to the development of cysts as being due to mucoid degeneration (1, 2, 5). In the papers mentioned (7, 8) the writer submitted the opinion that the process was not degenerative because, in the mucoid areas, the cells were well developed, the nuclei did not indicate any degenerative change, and in the protoplasm of the cells there were secretion droplets.

In so far that in the fully developed condition there are no apparent cells in the cyst fluid, the cells originally occupying this area must have died. To this extent a "degeneration" has occurred. However the problem is whether this degeneration is primary or merely incidental to the particular form of cellular activity and also probably to the segregation of the cells from their blood supply by the very mass of mucoid material formed and therefore secondary to such activity. It would seem reasonable not to employ the term "degeneration," which has come to be used loosely, for conditions which are normal and physiological. It is not employed in describing secretion, e.g., in the epithelium of the alimentary canal, where some cells are cast off during secretory activity. *A priori*, since degeneration means a breaking down it seems unlikely that such a process could result in the formation of a very complex protein—a form of mucin.

In the material presented here there is another item of evidence. In the areas of mucoid change there are, in the enlarged cells, extraordinarily well formed, indeed complicated, Golgi bodies. Many of these present a complex and intricate structure. Their complexity apparently is due in large part to the accommodation in a relatively small space of a greatly hypertrophied structure. Surface irregularities are to be correlated with irregularities in the shape of cells. Spherical or ovoid cells contain rounded or ovoid bodies. In some of the smaller, i.e., those which are disintegrating—as do cells in active secretion elsewhere, e.g., mucous cells—the Golgi material is still well formed and is just as deeply staining as is the material in the larger cells or the normal cells in the same section but at a distance from the affected area. Indeed, all the Golgi material in the "degenerative" regions is much more obvious than is that in the normal zones. Several of the observations which I have made on synovial membrane were first carried out in this tissue, the significance of minor variations of structure, etc., only becoming apparent in these robust and easily observed bodies.

From the point of view of the Golgi apparatus therefore there is no evidence of "degeneration" in the areas of mucoid accumulation until a very late stage. The affected cells show, for a considerable time, a normal or active nucleus and normal though more voluminous protoplasm containing well developed organoids.

SUMMARY

The tissue cells of ganglia and cysts of the menisci contain droplets of mucinoid mate-

rial, etc., which resemble the results of cellular activity more closely than those of protoplasmic disintegration.

The Golgi apparatus of these cells is hypertrophied and extremely complex in structure and this strongly supports the view that cytological changes are due to cellular activity rather than retrogression.

Since some forms of physiological secretory activity result ultimately in disappearance of cells, this might be regarded as a "degeneration," but in such cases this is a normal process and thus is different in degree as well as in kind from other true (or primary) degenerative conditions. The formation of normal joint fluid is such a process, and the changes in ganglia, etc., are of the same kind.

The areas of intercellular mucinoid "degeneration," which are the early stage of development of cells, are thus the result of secretion.

Ganglia and cysts of the menisci therefore may be regarded as abnormal new "joint spaces" and are not fundamentally "degenerative."

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IRRITATION OF THE RESPIRATORY TRACT AND ITS REFLEX EFFECT UPON THE HEART

L. CORSAN REID, M.D., and DONALD E. BRACE, M.D., New York, New York

IT has been recognized for some time that during anesthesia with intratracheal technique, particularly in the lighter planes, there may arise abruptly, dramatically marked respiratory difficulty and very obvious circulatory derangement. Probably, this happens most frequently with cyclopropane. These disturbances, however, after a variable period of time suddenly vanish leaving no clue as to their causal genesis or of the mechanism of their disappearance.

These phenomena seemed worthy of investigation by means of the electrocardiograph especially in regard to the part played by the heart in these circulatory derangements. It was felt that various mechanical appliances regularly employed in the closed types of anesthesia might play a provocative rôle in these most undesirable reactions. Accordingly, a series of patients who received uniform pre-operative preparation but different anesthetic agents were studied by the electrocardiograph, during the actual insertion of the tube, inflation of the cuff, spraying of the throat, or the introduction of the bronchoscope. Many records were made both before and immediately after instituting these different forms of irritation in the respiratory tract.

The present study embraces 35 patients. While electrocardiographic changes appeared in a fairly high percentage, in 10 there seemed to be indisputable reflex effects upon the heart as a result of the irritation of the mechanical agents used in the respiratory tract. Seven of these cases are presented as illustrating the wide variety of cardiac reactions encountered.

PRESENTATION OF CASES

CASE 1. No. 3368. Lead 2 in Figure 1. Cyclopropane anesthesia was used. The left part of the upper tracing shows a regular sinus rhythm; the insertion of the tube coincides with the beginning of the tracing; there appears suddenly marked vagal inhibition with escape of deeper auricular centers and also escape of one ventricular center; then a group of three auricular extrasystoles appears, followed by single extrasystoles. In the lower tracing one sees a similar arrhythmia with bradycardia and auricular extrasystoles during removal of the tube (at beginning of tracing) following which there is a rather rapid return to a normal sinus rhythm. In this part of the tracing there is some deformation of the tracing caused by movement of the patient.

CASE 2. No. 3558. Lead 2 in Figure 2. Cyclopropane anesthesia was used. In this case the tube was introduced and allowed to remain in position for a time. The white perpendicular line on the left side of the tracing is a signal marking the beginning of the inflation of the Water's cuff; one sees immediately, thereafter, prolongation of the *P-R* interval in some beats, marked prolongation of conduction time of a few auricular extrasystoles and later vagal inhibition with one escape beat; then a return to normal sinus rhythm.

CASE 3. No. 3286. Lead 2 in Figure 3. Cyclopropane, nitrous oxide, oxygen and ether anesthesia was used. In this case a regular sinus rhythm is present until insertion of the tube when immediately ventricular extrasystoles appear with an escape beat after the first extrasystole.

CASE 4. No. 3264. Lead 2 in Figure 4. Cyclopropane, nitrous oxide, oxygen, and ether anesthesia was used. The tracing at the left, before tube insertion, and the one at the right, after tube insertion, show regular sinus rhythm. In the middle portion of the tracing only, during insertion of the tube, one sees variform ventricular extrasystoles.

CASE 5. No. 3362. Lead 2 in Figure 5. Nitrous oxide, oxygen, and ether anesthesia was used. Upper tracing shows a regular sinus rhythm with low *T*-waves. During insertion of tube, lower tracing, the sinus rhythm disappears and a regular auriculoventricular rhythm appears without *P*-waves; near the end of the tracing sinus rhythm reappears.

CASE 6. No. 3425. Lead 2 in Figure 6. Nitrous oxide and oxygen anesthesia was used. Upper tracing represents a control with regular sinus rhythm. During insertion of the tube, left lower tracing, a marked bradycardia appears with blocked auricular extrasystoles. Then the registration had to be stopped because of patient moving; following which, in the right lower tracing, is seen a gradual disappearance of bradycardia with return of normal sinus rhythm.

From the New York Medical College and Flower-Fifth Ave Hospitals.

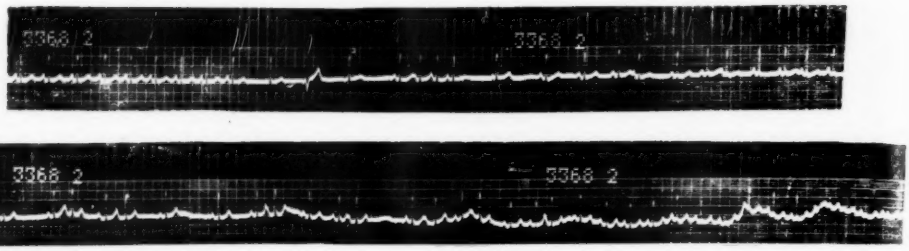

Fig. 1. 3368. Vagus inhibition with escape of deeper centers and auricular extrasystoles during insertion of tube and reappearance of normal rhythm immediately after tube removal (cyclopropane).

CASE 7. No. 3413. Lead 3 in Figure 7. Nitrous oxide and oxygen anesthesia was used. The upper tracing shows a regular sinus tachycardia with low *T*-waves. During insertion of tube, lower tracing, many auricular extrasystoles appear and the heart rate increases.

These tracings show such alterations as extrasystoles, both auricular and ventricular, delayed conduction time, slowing of the heart with escape of deeper centers, etc. It is well known that arrhythmias during anesthesia, particularly with cyclopropane, are very common. However, in our experiments it was very striking that these changes in the electrocardiogram occurred only during the mechanical irritation caused by insertion of the tube or inflation of the cuff, etc., and disappeared when the irritation had ceased. Moreover, according to Robbins and Baxter, prolongation of the *P-R* interval and the severer types of auriculoventricular block cannot be assumed to be an effect of cyclopropane.

The explanation of these effects on the heart coming on immediately after insertion of the tube or inflation of cuff, etc., and occurring at no other time, can be explained adequately only by assuming a sudden increase in vagal tone. This is intelligible only in terms of a reflex, in these instances, from the upper respiratory tract to the heart.

The evidence that such cardiac reflexes are of a vagovagal type, whether originating in the trachea, larynx, bronchi, or lung is substantiated in a way by the fact that all these effects can be duplicated by carotid sinus reflexes (6, 11); moreover, the injection of acetylcholine has given very similar electrocardiographic findings, Scherf (20) and Barnes (16).

HISTORY

The older literature contains many references to pulmocardiac reflexes (4, 9, 19) and these have been further extended by many recent contributions (12, 25), all of which have been well summarized by Schweitzer. There are two obvious ways of explaining these effects:

1. Reflex effects upon the heart centers, such as sinus node, auricular-ventricular node, etc. The inhibition of the heart such as bradycardia and auriculoventricular block as well as auricular and ventricular extrasystoles may very well follow, as is well known, from vagal effects being transferred to the specific tissue or to the myocardium itself.

2. Reflex effects on the coronary artery with alteration in blood flow volume and rate, etc. The extrasystoles might also be explained upon the basis of a pulmocoronary reflex. This pulmocoronary reflex was first suggested by Scherf, and it is well known that the electrocardiogram in pulmonary embolism may be similar and frequently is indistinguishable from that found in coronary

Fig. 2. 3558. Prolonged conduction time, sinus inhibition and escape beat during cuff inflation (cyclopropane).

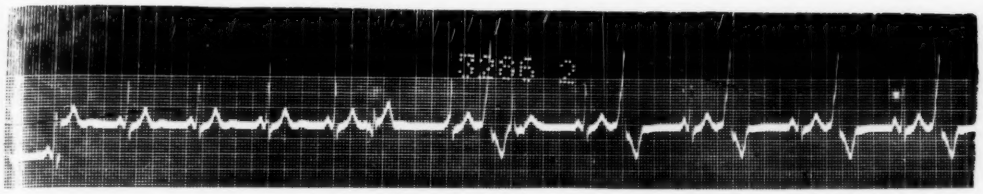

Fig. 3. 3286. Ventricular extrasystoles immediately after insertion of tube (cyclopropane, N_2O, O_2, ether).

thrombosis. Decreased coronary blood flow may very well initiate extrasystoles, but due to the type of *T*-wave found in the electrocardiograms of the present study it is not probable that there was a particularly marked decrease in the blood flow in any very large or extensive areas of the myocardium.

The experimental contributions in the literature which would substantiate this reflex conception are many, and a few may be mentioned at this time. One of the best known is the so called Kratschmer reflex in which irritation of the nasal mucosa by gases, faradic currents etc., gives rise to cardiac inhibition and respiratory disturbances. Churchill and Cope have shown that the slowing of the heart and the rapid shallow breathing in congestion and edema of the lungs are dependent upon a nervous mechanism, and this is probably a vagovagal reflex from the lungs to the respiratory center and heart. Harrison et al. (7, 8) have shown that increased pulmonary blood pressure either arterial, capillary, or venous, reflexly stimulated respiration but no effect took place if the vagi were cut. H. E. Hering (10) in 1920, showed pressure on larynx of the rabbit produced bradycardia; others have found the same effect in anesthetized dogs, also that it disappeared after atropinization. Sauerbruch (18), in 1932, described cardiac inhibition of such severity as occasionally to lead to death at the very instant the bronchus was constricted. Felix has made similar, even more suggestive, observations, in that repeated trauma to the bronchial mucous membrane led to cardiac arrest, and what is particularly important this occurred only during the bronchial irritation.

R. Nissen reported that on constricting a bronchus during a lobectomy in a girl of 12 years, there arose a temporary cardiac arrest, and subsequent touching of the bronchus gave a similar result. Adrian has shown that pulling up on the trachea increases the number of afferent vagal impulses, while pulling down decreased them.

The anatomical basis of the foci for the origination of these reflexes has recently been described by several workers. According to O. Larsell there are three groups of nerve plexuses in the lung: (1) bronchial group, (2) vascular group, and (3) pleural group. More recently, Sunder-Plassmann has brought excellent anatomical evidence to support this conception, and has added details of the nerve distribution in the intrapulmonary bronchi. Sunder-Plassmann states that the nerve supply to the bronchi is not unlike that of the gut, and he has demonstrated the existence of large numbers of nerve elements in the heavy connective tissue arranged in bundles around the bronchi. He also described other forms of nerve receptor elements in the epithelium of the intrapulmonary bronchi.

The course taken by the impulses originating in the respiratory passages apparently may take one of three different paths and

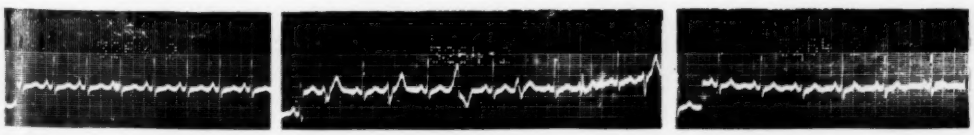

Fig. 4. 3264. Variable forms of ventricular extrasystoles during insertion of tube (cyclopropane, N_2O, O_2, ether).

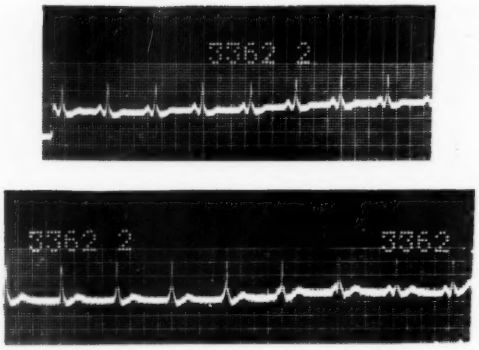

Fig. 5. 3362. Auricular ventricular rhythm during insertion of tube (N_2O, O_2, ether).

possibly, under certain conditions, may travel over all. These are: (1) impulses originating in respiratory passages may go by afferent vagal fibers to the vagal center and then by efferent fibers to the heart; (2) axon reflexes within the vagal network, and hence pass from lung to heart without going through the centers; (3) spread or irradiation of vagal impulses through various ganglia to the sympathetic nerves and hence to the heart.

The first would seem to be the most frequent occurrence, and undoubtedly, impulses arriving at the vagal center over the afferent nerve would spread to involve the respiratory center as well as efferently to heart. In addition there are direct afferent vagal fibers to the respiratory center. The second probably occurs although the experimental evidence for it is not complete. It was found by Carlson and Luckhardt that electrical stimulation of a lung in decerebrate frogs and turtles produced reactions on the heart and blood pressure. Others have reported similar findings. This represents some form of axon reflex within the autonomic nervous system. Also in this connection it should be mentioned that Somma Weiss has produced similar electrocardiographic tracings by inflating a balloon in an esophageal diverticulum. The electrocardiographic alterations were prevented by atropine. This leads one to suggest that the respiratory passages are potential foci for the origin of vagovagal reflexes which may be initiated by mechanical irritation from various agents, such as catheters, McGill tubes, cuff inflations, bronchoscopes, spraying of the throat, etc. These reflexes may then produce either a narrowing of the coronaries with resulting decrease in myocardial blood flow or induce profound alterations in the reaction of the specific tissue of the heart. The net result of this is usually a marked derangement of cardiac activity.

Regarding the respiratory disturbance it may be said that this is also assumed to be of reflex origin, the reflexes having the same source and initiating cause. The evidence for this respiratory reflex is not so complete as that for the heart; however, when one considers the abruptness of onset, the intimate association with obvious mechanical irritation, and the rapidity of its disappearance, the assumption of a reflex mechanism seems to have considerable basis. For example, it is well known that deep inspiration and expiration combined with coughing and closing of the glottis can produce extrasystoles, or if present

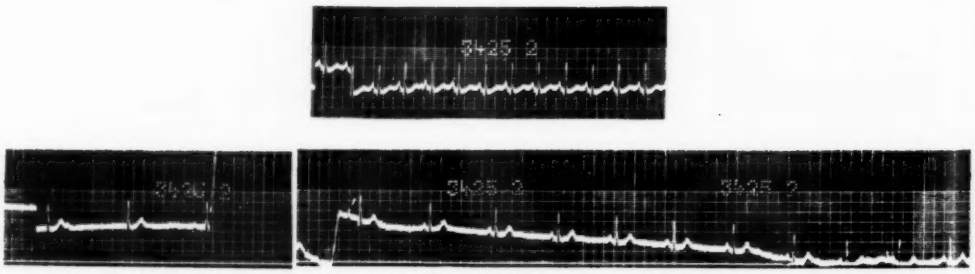

Fig. 6. 3425. Auricular ventricular block and marked bradycardia with escape beats during insertion of tube (N_2O and O_2).

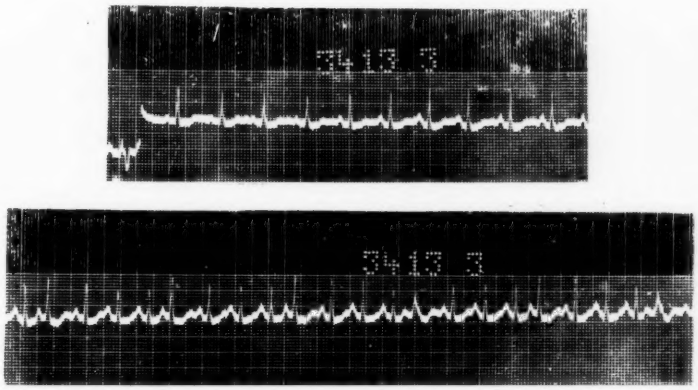

Fig. 7. 3413. Tachycardia and auricular extrasystoles during insertion of tube (N_2O, O_2) LD. 3.

even cause them to vanish. This fact finds therapeutic application by some patients with paroxysmal tachycardia, sometimes with quite spectacularly beneficial results. Of course, it is self evident that the percentage of occurrences depends on several conditions among which may be mentioned state of receptors in trachea, bronchi, etc., the status of the autonomic nervous system, and the state of the effectors in heart, vagal center, and respiratory center.

The occurrence of such a high percentage of alterations in the electrocardiograms in this investigation may very well be explained on the changes in the cardiac effectors because of the action of an anesthetic agent. Accordingly, there is clinical and experimental evidence which indicates that reflexes originating in the respiratory tract and passing to the heart, vagovagal in type, can be initiated rather frequently on the introduction of mechanical agents of various kinds into the respiratory passages. This mechanism may serve to explain many sudden deaths such as occur on water emersion when no water is present in the lungs and resuscitation fails (Scherf and Boyd, 21).

It might be recalled here that morphine increases vagal tone and therefore has a tendency to enhance or potentiate the action of vagal reflexes. This is important in view of its widespread use as a pre-operative medication. On the other hand, atropine has a highly specific effect in abolishing or minimizing vagal effects, and therefore would seem to possess the great advantage of decreasing if not actually preventing many of the undesirable features potentially present in vagovagal reflexes. This would seem to constitute excellent evidence as to its high value in pre-operative preparation and gives further justification for its almost universal use combined with morphine under these circumstances.

SUMMARY

1. Irritation of any kind, particularly that of mechanical agents in the respiratory tract may initiate reflexes within the autonomic nervous system having as its result, cardiac inhibition with altered function of the specific tissue, and resulting in a marked circulatory derangement.

2. These same irritations may set up reflexes leading to marked effect on respiratory center with profound alteration in respiratory activity.

3. These reflexes are very important at any time, but particularly so in light anesthesia or in structurally altered hearts, for all hearts under anesthesia are functionally deranged. In other words, a normal heart under anesthesia is vulnerable to derangement from vagal stimulation or vagovagal reflexes as is a structurally altered heart without anesthesia.

4. The conclusion seems warranted that the introduction of mechanical devices into

the respiratory tract, especially in light anesthesia, is not without danger, and all such contemplated procedures should have adequate pre-operative therapy, the object of which should be the minimization or prevention of the undesirable reactions potentially present in autonomic reflexes.

The authors wish to express their thanks to Professor L. J. Boyd for his help in preparing the manuscript; to Dr. M. J. Raisbeck for reports on the electrocardiograms, and Miss Mary Kondrajian for her excellent technical assistance.

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MALIGNANT DISEASE OF THE FACE, MOUTH, PHARYNX AND LARYNX IN THE FIRST THREE DECADES OF LIFE

GORDON B. NEW, M.D., F.A.C.S., and CHARLES S. HERTZ, M.D.,
Rochester, Minnesota

IT is generally thought that malignant disease rarely occurs in the face, mouth, antrum, pharynx, and larynx in the first three decades of life, and that when it does occur, it is very difficult to control and that few of the patients treated survive over a period of years. In order to obtain the facts, we have reviewed the histories of all patients less than 30 years of age who had malignant disease in this region for the period from 1907 to 1932. While there were a considerable number of cases in which a clinical diagnosis of malignant disease was made, there were only 233 in which we were able to obtain material from which to make a histological diagnosis. Eighty per cent of these patients were traced, and the high percentage of survivals without recurrence for 5 and 10 years after treatment is quite striking.

FACE

The patients with malignant lesions of the cheek, nose, forehead, scalp, temporal region, and ears have been included in this group. There were 49 such patients, of whom 31 were males and 18 females. These tumors of the face represented the greatest variation in type: 12 were basal cell epitheliomas; 8, squamous cell epitheliomas; 9, combined basal cell and grade 1 squamous cell epitheliomas; and 5, melano-epitheliomas. In addition there was 1 adenocarcinoma, 3 adenocarcinomas of the mixed type, 2 hemangio-endotheliomas, 8 fibrosarcomas, and 1 lymphosarcoma.

The methods of treating epithelioma of the face at the clinic have been given previously (10).

From the Section on Laryngology, Oral and Plastic Surgery, The Mayo Clinic, and the Section on Surgery, The Mayo Foundation.

Abridgment of thesis submitted by Dr. Hertz to the Faculty of The Graduate School of the University of Minnesota in partial fulfillment of the requirements for the degree of Master of Science in Surgery.

As shown in Table I, all the traced patients with basal cell or combined basal cell and grade 1 squamous cell epithelioma of the face survived at least 5 years without recurrence. These tumors are of a low grade of malignancy, as evidenced by their long duration, the absence of metastasis, and their good response to treatment.

Eight of these 49 patients with lesions of the face had fibrosarcomas. Six of these 8 patients were less than 20 years of age, the youngest being only 7 years old. There were 5 cases of melano-epithelioma, 3 of the cheek, and 1 each of the parotid region and ear. Contrary to usual experience, the patients with melano-epithelioma in the present study did remarkably well. Four of the 5 were traced. One died from the disease but the 3 others are alive and well 5 years or more after treatment (Fig. 1).

Five patients had multiple lesions of the face. These consisted chiefly of basal cell epitheliomas and basal cell and grade 1 squamous cell epitheliomas combined. All these patients were living 5 years or more after surgical treatment.

There was 1 case of lymphangio-endothelioma of the cheek. The patient was a girl, 9 months old. The lesion was treated with radium and at the last report the patient was living and well 15 years later.

On analysis of these malignant lesions of the face it is found that of 30 patients who were traced, 77 per cent were alive and well 5 years and 71 per cent 10 years after treatment.

LIPS

Epithelioma of the lip is the most common form of malignant disease of the face and, according to Boyd, accounts for 2 per cent of all deaths from cancer. While it is undoubtedly a lesion of the later decades of life, it does occur in the earlier decades as well. A 6 year

Fig. 1. Melano-epithelioma of the cheek, with metastatic involvement of two upper cervical lymph nodes of a man, 28 years of age. Patient was alive and well 10 years after removal of the tumor and dissection of the neck.

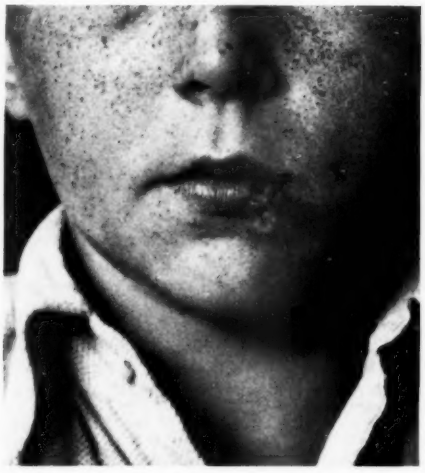

Fig. 2. Boy, 13 years of age, with squamous cell epithelioma, grade 1, of the lower lip.

old boy who had metastasis to the submaxillary lymph nodes is the youngest patient known to have had an epithelioma of the lower lip. This case has been reported by Kondratenko.

The youngest patient in our series was a boy of 13 years (Fig. 2) who had a grade 1 squamous cell epithelioma of the lower lip. When last heard from he was alive and well 6 years after operation.

Forty-three of our 233 patients (18.5 per cent) had squamous cell epithelioma of the lower lip. One additional patient had a basal cell epithelioma of the upper lip. Of this group of 43 patients, 20 gave a history of a preceding lesion such as a crack, fissure, or scaling area. Thirty-nine of these patients were males and 4 were females. The average duration of signs or symptoms before these patients came to the clinic was 1.8 years.

Eighteen of these patients had lesions of grade 1 malignancy, 18 of grade 2, 5 of grade 3, and 2 of grade 4. In other words, 36 (84 per cent) of these squamous cell epitheliomas of the lower lip were of the two lower grades of malignancy. In a much larger series of cases of similar lesions in patients of all ages, Broders found that 78 per cent were of the two lower grades of malignancy. The method of treatment used for cancer of the lip has been given before by one of us (New, 5).

Of the total of 44 cases of epithelioma of the lip, 5 showed involvement of the cervical lymph nodes as proved by microscopic examination. Four of these 5 patients died

TABLE I.—FIVE YEAR SURVIVALS ACCORDING TO TYPE OF LESION

Lesion	Patients treated	Patients traced	Lived 5 years or more after treatment	
			Number	Per cent of those traced
Squamous cell epithelioma, grade 1	22	20	18	90.0
Squamous cell epithelioma, grade 2	27	25	17	68.0
Squamous cell epithelioma, grade 3	15	13	7	53.8
Squamous cell epithelioma, grade 4	29	26	1	3.8
Basal cell, and basal and squamous cell, epithelioma, grade 1	17	8	8	100.0
Adenocarcinoma (mixed tumor)	62	50	44	88.0
Fibrosarcoma	17	13	7	53.8
Lymphosarcoma	11	9	2	22.2
Melano-epithelioma	5	4	3	—
Lymphangio- and hemangio-endothelioma	5	5	3	—
Miscellaneous	9	8	5	—
Total	219	181	115	63.5

within 2.2 years; the remaining patient was living and well 11 years after surgical treatment. This emphasizes the fact that metastasis to the lymph nodes renders the prognosis much more grave, although the fact that 1 patient who had a squamous cell epithelioma of grade 3 was living and well 11 years later shows that the prognosis is not hopeless. In this latter case the lip lesion was excised, with bilateral dissection of the lymph nodes of the neck. Twenty-seven other patients in this group underwent bilateral dissection of the cervical lymph nodes but none of the nodes showed any evidence of metastasis. Twenty-two of these patients were traced: 2 died within 2½ years, whereas the 20 remaining lived 5 years or more. Tables II and III reveal further that approximately 84 per cent of the patients who were traced were living 5 years or more, and 78 per cent were living 10 years or more after treatment. These figures compare favorably with those reported previously. In a much larger series of cases of epithelioma of the lower lip, irrespective of age, it was found that 75 per cent of the patients lived 5 years or more (5).

While the number of patients in this group is small, it seems reasonable to conclude from these data that the prognosis for epithelioma of the lower lip in persons less than 30 years of age is apparently just about as good as that in older persons, probably owing to the large percentage of growths of low grade malignancy.

TABLE II.—FIVE YEAR SURVIVALS ACCORDING TO LOCATION

Location	Patients treated	Patients traced	Lived 5 years or more after treatment	
			Number	Per cent of traced patients
Face	44	30	23	76.7
Parotid and submaxillary region	51	41	37	90.2
Lips	43	38	32	84.2
Tongue, palate, tonsil, pharynx	47	41	12	29.3
Upper jaw and antrum	20	19	7	—
Lower jaw	8	7	3	—
Larynx	6	6	2	—
Total	219	182	116	63.7

83 per cent traced 5 years or more

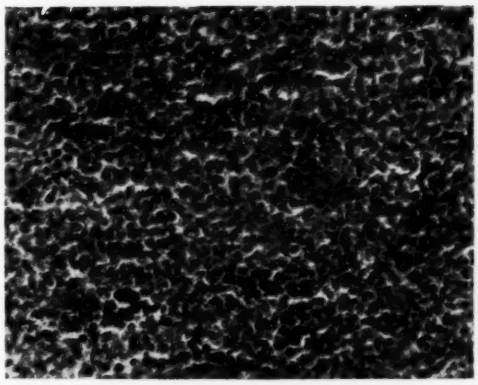

Fig. 3. Lymphosarcoma of the antrum of a woman, 26 years of age, treated with radium and roentgen rays. Patient was alive and well 9 years later.

ANTRUM AND UPPER AND LOWER JAWS

The antrum of Highmore may be the seat of a large variety of tumors, both benign and malignant. Both carcinoma and sarcoma may occur. One of us (New, 5) in a large series of cases found that squamous cell carcinoma is the predominant tumor involving the upper jaw and antrum.

There were 31 cases of malignant neoplasms of the antrum and of the upper and lower jaws in this series. Of the 16 tumors primarily involving the antrum, 8 were squamous cell carcinomas, 3 lymphosarcomas (Fig. 3), 2 fibrosarcomas, and 1 each of the following: hemangio-endothelioma, adenocarcinoma, and adenocarcinoma of the mixed tumor type. Of the 6 tumors of the upper jaw, 2 were squamous cell carcinomas, 2 fibrosarcomas, and 2 adenocarcinomas, 1 being of the mixed tumor type. There were therefore 22 tumors of the upper jaw and antrum (almost 10 per cent of the entire series), and, of these, 10 were squamous cell carcinomas. Nine of these 10 were grade 3 or 4 malignancy.

The youngest patients in this group were a 2 year old boy who had a fibrosarcoma of the lower jaw, and a 4 year old girl, who had a fibrosarcoma, apparently primary in the upper jaw.

The average duration of symptoms for tumors of the antrum before the patient came to the clinic was 7 months, 1.3 years for lesions

TABLE III.—TEN YEAR SURVIVALS ACCORDING TO LOCATION

Location	Patients treated	Patients traced	Lived 10 years or more after treatment	
			Number	Per cent of traced patients
Face	31	21	15	71.4
Parotid and submaxillary region	26	19	14	73.7
Lips	32	27	21	77.8
Tongue, palate, tonsil, pharynx	24	22	4	18.2
Upper jaw and antrum	11	10	5	—
Lower jaw	3	3	2	—
Larynx	1	1	0	—
Total	128	103	61	59.2

80 per cent traced 10 years or more

of the upper jaw, and 2.3 years for lesions of the lower jaw.

The method of treating malignant tumors of the jaws and antrum has been described previously (5).

In view of the fact that the number of patients in this group is so small, we have not given any percentage figures in the survival tables (Tables II and III). Cabot and one of us (New) reported for all age groups the following 5 year survival figures: for malignant growths of the upper jaw and antrum, 54 per cent, for malignant growths of the lower jaw, 60 per cent.

BUCCAL CAVITY AND PHARYNX

Malignant neoplasms of the tongue are usually squamous cell carcinomas. A few rare cases of sarcoma have been reported. Carcinoma of the tongue, despite the fact that it is readily recognizable in its early stages, is nevertheless one of the most fatal of malignant diseases.

Malignant neoplasms of the palate are usually adenocarcinomas of the mixed tumor type or squamous cell epitheliomas. Sarcomas may also be found in this region, but they are less common than the other types.

Malignant tumors of the tonsil are usually squamous cell carcinomas, one of us (New) and Childrey having found such lesions to be almost five times as common as all other types of malignancy of the tonsil combined.

There were 6 cases of malignancy of the tongue in our series, all squamous cell epitheliomas and 5 of the 6 tumors were of the higher grades of malignancy. There was only 1 tumor of the tonsil, a lymphosarcoma. Of the 7 tumors of the palate, 5 were adenocarcinomas of the mixed tumor type, the 2 remaining being, respectively, a fibromyxosarcoma and a hemangio-endothelioma. The largest number of neoplasms in this group were in the pharynx. Of these 37 growths, 21 were squamous cell epitheliomas, 6 were lymphosarcomas, 5 were adenocarcinomas of the mixed tumor type, 3 were fibrosarcomas, 1 was a hemangio-endothelioma, and 1 was an adenocarcinoma. The pharyngeal epitheliomas were all of grades 3 and 4.

The youngest patient with cancer of the tongue was a woman (Fig. 4), 22 years old, who had a grade 4 squamous cell epithelioma involving the tip of the tongue. This is a very unusual case because, following radium and roentgen therapy, this patient was still living and well 5½ years after treatment. (During the past year a 13 year old boy (Fig. 5) who had a grade 4 squamous cell epithelioma on the left margin and base of the tongue was seen at the clinic.) A 7 year old girl was the youngest patient with a malignant lesion of the palate. She had a fibromyxosarcoma and died 3 months after treatment. The 1 patient with lymphosarcoma of the tonsil was a man 29 years old. He died 8 months after the onset of symptoms. The youngest patient with a pharyngeal lesion was a boy, 3 years old, with grade 4 squamous cell epithelioma. He died within 2 months of the onset of symptoms.

The method of treatment of malignant disease of the tongue, tonsil, pharynx, and palate has been described previously.

Tables II and III reveal the high mortality for this group of lesions. After 5 years, only 29 per cent of the 41 patients who were traced were alive, and 10 years after treatment only 18 per cent of the 22 patients who were traced were alive. This is undoubtedly partly due to the fact that the lesions were of such a high grade of malignancy. Twenty-six of the 27 squamous cell epitheliomas were of either grade 3 or 4, which again gives much support to Broders' thesis that the most important

Fig. 4. Woman, 22 years of age, with squamous cell epithelioma, grade 4, of the tip of the tongue. The growth had not recurred 8 years following its removal and treatment with radium.

factor in prognosis is the grade of malignancy. The high mortality for this group of patients with lesions of the tongue, palate, tonsil, and pharynx corresponds in a general way to the statistics for all age groups. One of us (New, 5) in a series of 156 traced patients who had epithelioma of the tongue, reported that 37 per cent were living 5 years or more after treatment. Figi and one of us (New) reported 26 per cent of patients with epitheliomas of the pharynx and tonsil living 5 years, and 54 per cent with lymphosarcomas in the same region living 5 years after treatment.

LARYNX

Malignant tumors of the larynx are infrequent in persons less than 30 years of age, although they do occur. Recognition of this fact is of great value from the standpoint of diagnosis and treatment.

Of the malignant growths in this region the majority are of epithelial origin. Sarcoma is infrequent. The typical neoplasm is the squamous cell epithelioma.

Carcinoma of the larynx is most common in adults beyond middle age, and it is much more common in men than in women. In a group of more than 380 cases Figi and one of us (New, 3) found that 84 per cent of the patients were between 40 and 70 years of age; only 5 per cent were less than 40.

Fig. 5. Boy, 13 years of age, with squamous cell epithelioma, grade 4, of the left margin and base of the tongue.

In our series there are 6 malignant neoplasms of the larynx. These were all squamous cell epitheliomas, 2 each of grades 2 and 3 (Fig. 6), and 1 each of grades 1 and 4. These 6 cases were divided equally with respect to sex. Four of the 6 patients were between 20 and 30 years of age. The youngest patient in this group was 2 years of age. She was first seen in 1929 and had had symptoms for a year. Microscopic examination revealed a papillary squamous cell epithelioma of grade 1. The patient was treated over a period of 3 years with roentgen rays, radium, and diathermy for recurrences, but she died eventually in 1934. The method of treating carcinoma of the larynx has been described previously (6).

The prognosis for carcinoma of the larynx in young persons is poor (Tables II and III). Of the 6 patients, 2 were alive and well 5 and 6 years, respectively, after surgical intervention. The 4 remaining died within 4 years.

In a group of 107 patients of all ages with carcinoma of the larynx Figi and one of us (New, 9) reported 65 per cent living 5 years or

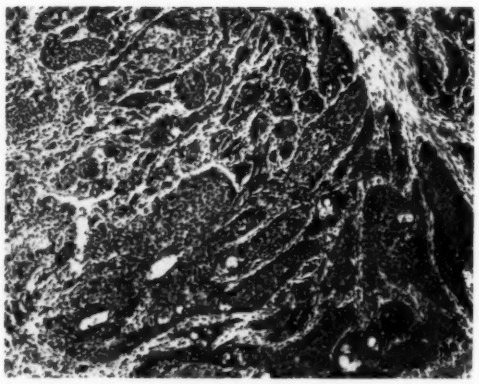

Fig. 6. Squamous cell epithelioma, grade 3, of the larynx of a boy, 15 years of age. There was no evidence of recurrence 5 years after operation.

more after operation. None of the patients who had a grade 4 carcinoma lived 5 years.

PAROTID AND SUBMAXILLARY REGIONS

Most of the neoplasms in this group are of the parotid region. We have considered in this group all tumors in and about the parotid and submaxillary salivary glands. In this series there were 52 cases of malignancy involving the parotid and submaxillary region. Forty-eight of the lesions were adenocarcinomas (mixed tumor type), 2 were squamous cell epitheliomas, 1 was a melano-epithelioma, and 1 a hemangio-endothelioma. Of the 52 patients, 31 were females, 21 males. The youngest patient in the group was a 7 year old boy. Sections through the tumor in this case showed typical adenocarcinoma plus a squamous cell epithelioma of grade 2. This boy was living 10 years after excision of the tumor and subsequent roentgen treatment.

The average duration of symptoms prior to the time this group of patients came to the clinic was 3.75 years. The usual low grade of malignancy of these tumors makes the prognosis much better than for other lesions in this study. Of the 41 patients who were traced, 37, or 90 per cent, were alive 5 years later (Table II). Of 19 traced and hence eligible for 10 year survey, 14, or 74 per cent, were alive.

Although the prognosis for these patients is good, one must always bear in mind that the tumors frequently recur if they are not completely removed at the primary operation. One of our patients first came to the clinic in 1918 at the age of 24 years with a recurrence after a former operation. He then returned several times later because of recurrences, and 20 years after his first visit he returned with an extensive recurrence.

SUMMARY AND COMMENT

This study was limited to patients in the first three decades of life. As was to be expected, the number of cases of malignant disease increased with each succeeding decade. It was interesting to note that the distribution by sex during the first and second decades was almost equal: 33 males to 30 females. It was in the third decade that the predominance of males occurred. In this decade there were 107 males as contrasted with 63 females.

It was of interest likewise to note the incidence of carcinoma and sarcoma. Twelve per cent of the lesions were sarcomas, 88 per cent carcinomas.

There were 100 cases of squamous cell epithelioma, and the 5 year survival figures (Table I) were similar to those of other observers. In other words there is real prognostic value in grading such malignancies, for one can offer the patients with grade 1 lesions a 90 per cent chance for recovery whereas the prognosis for those with grade 4 lesions is very poor. As was to be expected, patients with basal cell and combined basal cell and squamous cell epithelioma of grade 1 showed 100 per cent 5 year survivals. Eighty-eight per cent of the patients with adenocarcinoma of the mixed tumor type were alive 5 years after treatment. Patients with sarcomas had a poorer prognosis. Fifty-four per cent of the patients with fibrosarcoma were alive 5 years later. Only 22 per cent of those with lymphosarcoma lived 5 years.

Malignant disease of the tongue, palate, tonsil, pharynx, upper jaw and antrum, lower jaw and larynx, in young persons is thought to carry a very poor prognosis. Table II, however, shows that of the 73 patients who were traced, 24 (32.9 per cent) were living 5 years after treatment, and Table III shows that of the 36 patients who were traced, 11 (30.6 per

ent) were living 10 years after treatment. If one includes cancers of the lip, of the 111 patients who were traced, 56 (54.4 per cent) were living 5 years after treatment, and of 63 traced for 10 years, 32 (50.7 per cent) were living after treatment. Considering the locations of these neoplasms and the age of the patients, these survival figures are surprisingly high.

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AN EXPERIMENTAL STUDY OF URETERO-INTESTINAL IMPLANTATION

III. The Significance of Ureterocloacal Reimplantation in the Chicken

HENRY M. WEYRAUCH, Jr., A.B., M.D., F.A.C.S., and FRANK HINMAN, A.B., M.D., F.A.C.S.,
San Francisco, California

IT IS logical to assume that, if it were possible to reproduce exactly those conditions which exist in vertebrates whose ureters empty into a cloaca, the success of uretero-intestinal anastomosis would be assured. In these animal phyla the ureters open into a highly contaminated field without the occurrence of spontaneous infection of the urinary tract or other disastrous consequences. Smears and cultures of urine obtained from the ureters of 4 chickens failed to show the presence of any organisms. Nor was any evidence of renal infection observed upon the gross examination of 40 chickens and a microscopic examination of half this number. Identification by culture of the cloacal flora in 4 chickens demonstrated the pathogenicity of the natural content. Bacillus welchii was found in 2 instances, non-hemolytic Escherichia coli in 4, proteolytic flora in 3, Bacillus paracoli in 1 instance, and Staphylococcus albus in 1.

In a previous communication,[1] we have demonstrated the fact that there was no anatomical barrier to ascending infection at the ureterocloacal entrance although certain peculiarities, i.e., an abundance of lymphoid tissue and a columnar type of ureteral epithelium were noted. The purpose of the present study is to determine whether these peculiarities of structure or some power of natural resistance provide an immunity to infection of the urinary tract.

The problem has been attacked by observing the effects of ureterocloacal reimplantation in the chicken. It was reasoned that, if these animals possess such a natural immunity, ureterocloacal reimplantation should be a benign procedure, less hazardous than uretero-intestinal anastomosis in animals unaccustomed to a union of the urinary and intestinal tracts.

Because of the minute dimensions of the ureter and the feeble texture of the cloacal wall in the chicken, a submucosal or other elaborate type of ureterocloacal reimplantation was found impractical. For the present purpose, therefore, two simple operations were chosen: (1) a direct reimplantation following division of the ureter and (2) reimplantation of a rosette of cloacal wall bearing the intact ureteral orifice.

In both types of operation the exposure was identical, and the entire procedure was carried out extraperitoneally. The chicken was anesthetized with ether, and a wide area surrounding the anus was denuded of feathers and prepared with iodine. By straddling the legs of the fowl over a small sandbag placed beneath the hindquarters it was found possible to elevate the anal region in such a manner as to present a readily accessible operative field.

A curved incision 4 centimeters in length, which was made parallel and about 1 centimeter dorsal to the anus, permitted entry to the retroperitoneal space. Because of a close attachment to the vertebral column, careful dissection was found necessary to free the cloaca with the entering ureters. Identification of the ureters was facilitated by having an assistant insert an index finger into the cloaca in order to project the dorsal wall into the operative field. This procedure made readily possible the exposure of the ureters at their entrance into the cloaca (Fig. 1, A).

From the Department of Surgery, Division of Urology, University of California Medical School.

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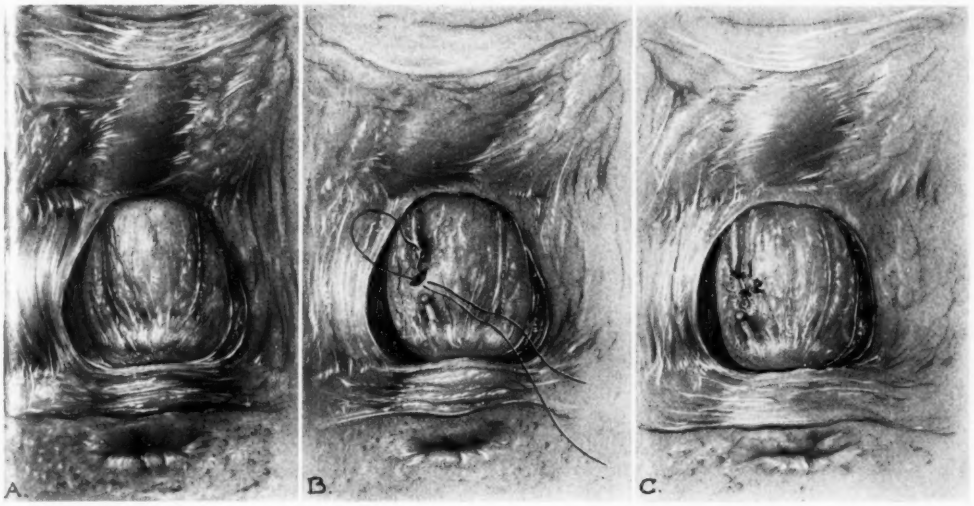

Fig. 1. Ureterocloacal reimplantation in the chicken. Direct method. A, Retroperitoneal exposure of cloaca with entering ureters. B, The left ureter has been divided, the distal stump ligated, and a transfixion suture placed through the proximal end. The suture has been introduced through an opening made into the lumen of the cloaca and is ready to be anchored in the wall of the cloaca a short distance beyond. C, Anastomosis completed. *1*, Suture closing opening in cloaca. *2*, Suture anchoring end of ureter.

In the direct method of reimplantation the ureter was dissected free and divided between clamps just proximal to its entrance into the cloaca. The distal stump was ligated with fine silk and the proximal end transfixed with a suture of No. 0000 chromic catgut on an atraumatic needle. The transfixion suture entered the lumen of the ureter and emerged a few millimeters from the end through its dorsal wall. The ureter was reimplanted into the cloaca through a small transverse incision made a short distance proximal to the normal orifice, the two ends of the transfixion suture being passed into the lumen of the cloaca and out through all layers of the cloaca at a point distal to the incision (Fig. 1, B). The end of the ureter was anchored by tying the transfixion suture, and the anastomosis was completed by closing the cloaca around the entrance of the ureter with one or more interrupted sutures of fine chromic catgut (Fig. 1, C).

In utilizing the intact orifice, the lower part of the ureter was dissected free and the region surrounding the ureteral orifice tented up by traction on the ureter, thus permitting excision of a rosette of cloacal wall surrounding the orifice. A transfixion suture of No. 0000 chromic catgut on an atraumatic needle was placed through the margin of the cuff, at a distance from the ureter, and anchored in a manner similar to the procedure in the previous operation (Fig. 2, A). The ureter was reimplanted into the opening made by excision of the ureteral orifice, and the wound was closed around the entering ureter with interrupted sutures of fine chromic catgut (Fig. 2, B).

Four one stage bilateral ureterocloacal reimplantations were performed, three by the direct method, one by the method of the intact orifice (Table I). All the chickens succumbed in from 2 to 5 days. In each instance the postoperative course was much the same. The chickens soon began to drink enormous quantities of water; they gradually became torpid; coma developed and death ensued. There was no means of estimating the urinary output. Although the excreta were noted to be more liquid than usual, this factor could be explained on the basis of the irregularities of the intestinal tract incident to the uremia.

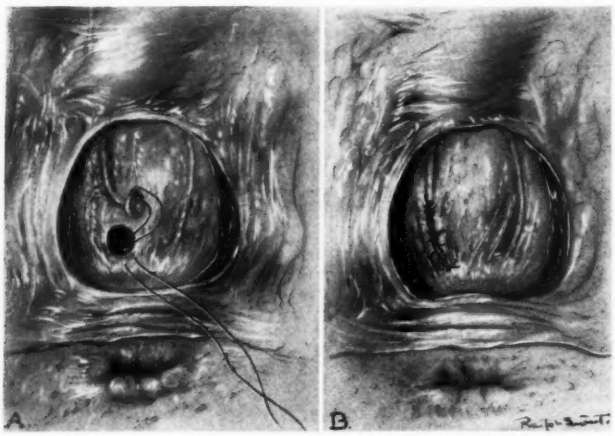

Fig. 2. Ureterocloacal reimplantation in the chicken. Method of the intact orifice. A, A circular area of cloacal wall bearing the intact ureterocloacal orifice has been excised and a transfixion suture placed through the periphery. The suture has been passed through the opening made in the cloaca and is ready to be anchored a short distance beyond. B, Anastomosis completed. The ureter is anchored in place and the opening in the cloaca has been closed around the entering ureter.

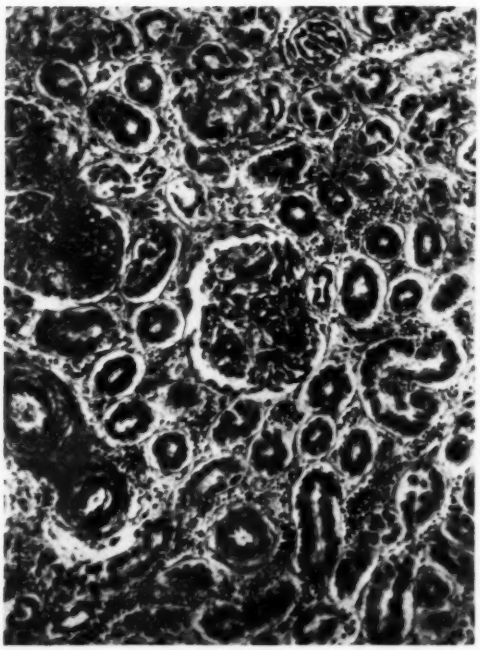

Fig. 3. Acute ascending pyelonephritis in the chicken. Death 3 days following operation (chicken 2, Table 1A).

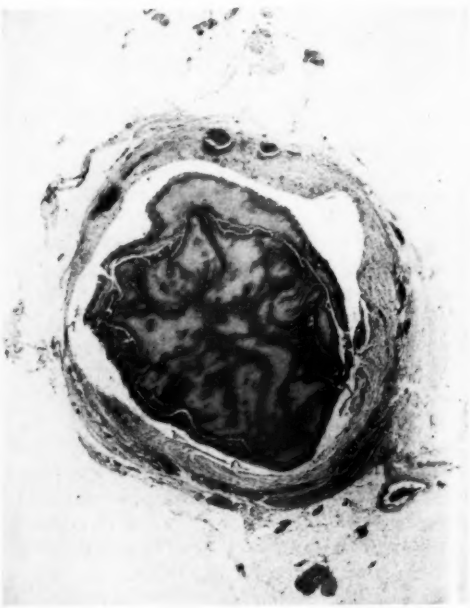

Fig. 4. Chronic ureteritis in the chicken. Ureter occluded with caked material. Sacrificed 32 days following operation (chicken 4, Table II).

TABLE I.—ONE STAGE BILATERAL URETEROCLOACAL REIMPLANTATION IN THE CHICKEN

No. and sex	Operation	Result	Obstruction of urinary tract		Ascending infection		Remarks
			Right	Left	Right	Left	
			A. Direct reimplantation				
1 Hen	Bilateral direct reimplantation	Died: 3 days	Hydronephrosis and hydro-ureter. Orifice occluded by caked material projecting into cloaca	Pyonephrosis and pyo-ureter. Orifice occluded by caked material projecting into cloaca	Acute pyelonephritis and ureteritis	Acute pyelonephritis and ureteritis	Infection of wound
2 Rooster	Bilateral direct reimplantation	Died: 3 days	Hydronephrosis and hydro-ureter. Orifice not patent	Hydronephrosis and hydro-ureter. Orifice not patent	Acute pyelonephritis and ureteritis	Acute pyelonephritis and ureteritis	Peritonitis. Infection of wound
3 Hen	Bilateral direct reimplantation	Died: 5 days	Hydronephrosis and hydro-ureter. Orifice not patent. Caked material adherent to projecting end of ureter	Hydronephrosis and hydro-ureter. Orifice not patent. Caked material adherent to projecting end of ureter	Acute pyelonephritis and ureteritis	Acute pyelonephritis and ureteritis	
			B. Reimplantation of intact orifice				
1 Rooster	Bilateral reimplantation of intact orifice	Died: 2 days	Hydronephrosis and hydro-ureter. Orifice not patent. Caked material adherent to projecting end of ureter	Slight dilatation of renal pelvis and ureter. Orifice not patent. Caked material adherent to projecting end of ureter	Acute pyelonephritis and ureteritis	Acute pyelonephritis and ureteritis	Peritonitis. Infection of wound

TABLE II.—UNILATERAL DIRECT URETEROCLOACAL REIMPLANTATION IN THE CHICKEN

No. and sex	Operation	Result	Necropsy		
			Obstruction of urinary tract	Ascending infection	Opposite kidney and ureter
1 Hen	Left direct reimplantation	Sacrificed: 5 days	Left: Hydronephrosis and hydro-ureter. Orifice not patent. Caked material adherent to projecting end of ureter	Left: Acute pyelonephritis and ureteritis	Right: normal
2 Hen	Right direct reimplantation	Sacrificed: 10 days	Right: Hydronephrosis and hydro-ureter. Orifice barely patent	Right: Chronic pyelonephritis and ureteritis	Left: normal
3 Hen	Left direct reimplantation	Sacrificed: 22 days	Left: Mild dilatation of renal pelvis and ureter. Orifice patent	Left: No infection	Right: normal
4 Hen	Right direct reimplantation	Sacrificed: 32 days	Right: Dilated renal pelvis and ureter. Kidney atrophic. Orifice not patent	Right: Chronic atrophic pyelonephritis and ureteritis. Pelvis and ureter filled with caked material	Left: normal
5 Rooster	Right direct reimplantation	Sacrificed: 47 days	Right: Mild dilatation of renal pelvis and ureter. Ureter barely patent	Right: Chronic atrophic pyelonephritis and ureteritis	Left: normal
6 Hen	Left direct reimplantation	Sacrificed: 48 days	Left: Hydronephrosis and hydro-ureter. Orifice patent	Left: Acute pyelonephritis and ureteritis	Right: normal
7 Hen	Left direct reimplantation	Sacrificed: 60 days	Left: Hydronephrosis and hydro-ureter. Orifice patent	Left: Chronic pyelonephritis and ureteritis	Right: normal

The clinical picture of death caused by acute uremia was confirmed at necropsy. In every instance there was complete obstruction of the urinary tract as well as an acute bilateral ascending renal infection (Fig. 3), as demonstrated by microscopic sections of the kidneys and ureters. The ureters and renal pelves were found to be dilated and, upon injection of the ureters, no fluid could be expressed into the cloaca. In some cases the obstruction was apparently caused by or contributed to by the presence of caked material which formed around the redundant intracloacal end of the ureter.

These universally fatal results made it necessary to resort to unilateral operations in order to study the prolonged effects of ureterocloacal reimplantation. In 7 unilateral direct reimplantations (Table II) and 8 unilateral reimplantations of the intact orifice (Table

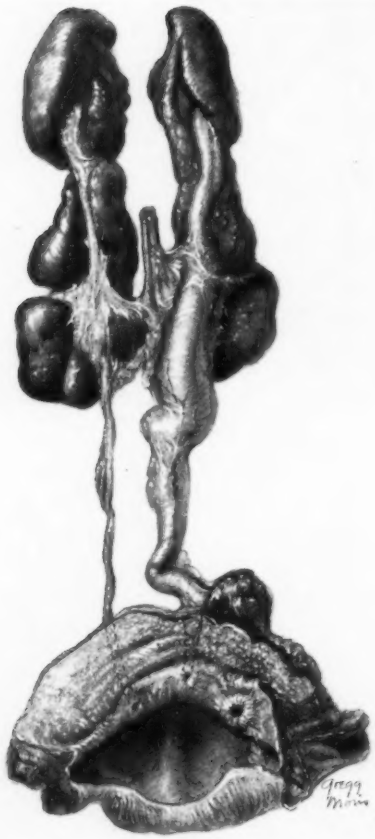

Fig. 5. Left hydronephrosis in the chicken. The renal pelvis and ureter are widely dilated. The orifice emits a small stream. Chicken sacrificed 10 days following operation. (No. 2, Table III.)

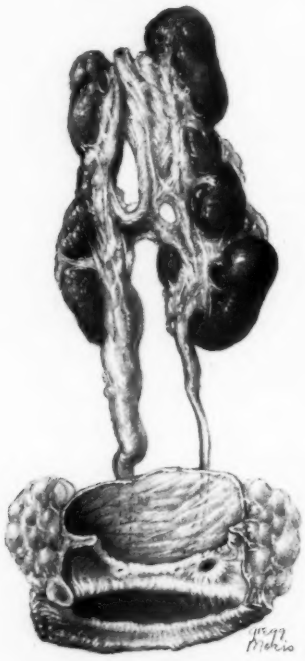

Fig. 6. Right hydronephrotic atrophy in the chicken. The kidney shows marked atrophy which is secondary to obstruction and infection. The renal pelvis and ureter are occluded with caked material (see Fig. 5). The orifice is not patent. There is compensatory hypertrophy of the left kidney. Sacrificed 32 days following operation (No. 4, Table II).

III) no death occurred. The chickens were sacrificed at intervals of from 5 to 60 days in order to observe the incidence of obstruction and the presence of infection of the upper urinary tract.

After passing through the phase of complete obstruction of the urinary tract immediately following operation, so well demonstrated in the bilateral series, communication was found to be re-established in many instances. In the 7 direct reimplantations the orifice was well open in 3 instances (No. 3 at 22 days, No 6 at 48 days, and No. 7 at 60 days). The orifice was capable of emitting a small stream in 2 additional instances (No. 2 at 10 days and No. 5 at 47 days). In one chicken (No. 4 at 32 days), the renal pelvis and entire ureter were occluded with caked material (Fig. 4). Of the 8 reimplantations of the intact orifice the opening was patulous in 5 instances (No. 1 at 5 days, No. 2 at 10 days, No. 5 at 21 days, No. 7 at 43 days, and No. 8 at 60 days). The effect of obstruction was a dilatation of the ureter and renal pelvis with varying degrees of hydronephrotic atrophy of the renal parenchyma (Figs. 5 and 6).

Whereas acute ascending infection was noted in all of the bilateral reimplantations,

as the time of survival was lengthened beyond 5 days, chronic pyelonephritis and ureteritis became the more usual findings (Fig. 7). In 1 of the 7 direct reimplantations (No. 3 at 21 days) and in 2 of the 8 reimplantations of the intact orifice (No. 5 at 21 days and No. 7 at 43 days) no inflammatory changes were found on microscopic examination. These findings do not preclude, of course, the occurrence of an early infection with resolution.

The incidence of obstruction of the urinary tract and ascending infection by the two methods is tabulated in Table IV. It will be noted that the use of the intact orifice was attended with slightly better results than direct reimplantation of the divided ureter. Even the former method, however, failed to exhibit any appreciable merit. Although the poor results may be partially attributed to the extremely small size of the ureter and the viscid consistency of the urine which, in a few cases, may have predisposed to caking within the ureter, these factors cannot be held entirely responsible in view of the development of a patent orifice in the majority of instances.

Summarizing the results of the 23 reimplantations by both methods, changes caused by obstruction of the urinary tract were found in 21 instances, or 91 per cent, and evidence

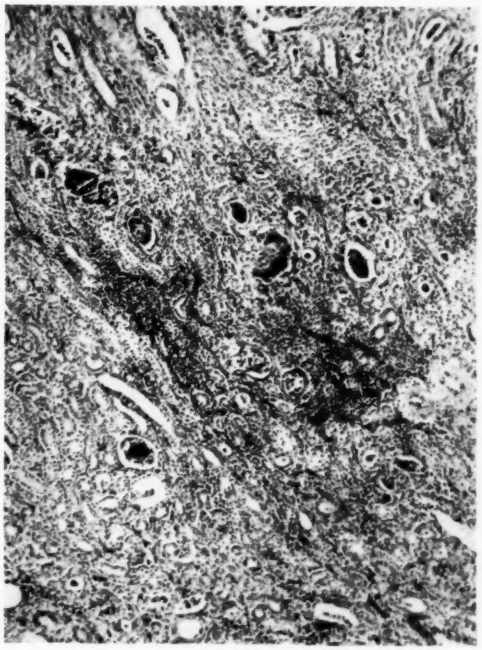

Fig. 7. Photomicrograph of specimen showing chronic ascending pyelonephritis in the chicken. The bird was sacrificed 30 days following operation (chicken 6, Table III).

TABLE III.—UNILATERAL URETEROCLOACAL REIMPLANTATION OF THE INTACT ORIFICE IN THE CHICKEN

No. and sex	Operation	Result	Necropsy		
			Obstruction of urinary tract	Ascending infection	Opposite kidney and ureter
1 Hen	Left intact orifice	Sacrificed: 5 days	Left: Hydronephrosis and hydroureter. Orifice patent	Left: Mild pyelitis and ureteritis	Right: normal
2 Hen	Left intact orifice	Sacrificed: 10 days	Left: Hydronephrosis and hydroureter. Orifice patent	Left: Chronic pyelonephritis and ureteritis	Right: normal
3 Hen	Right intact orifice	Sacrificed: 15 days	Right: Hydronephrosis and hydroureter. Atrophy of kidney. Orifice not patent	Right: Chronic atrophic pyelonephritis and ureteritis	Left: normal
4 Hen	Left intact orifice	Sacrificed: 21 days	Left: Hydronephrosis and hydroureter. Orifice not patent	Left: Chronic pyelonephritis and ureteritis	Right: normal
5 Hen	Right intact orifice	Sacrificed: 21 days	Right: Hydronephrosis, mild hydroureter. Orifice patent	Right: No infection	Left: normal
6 Hen	Left intact orifice	Sacrificed: 30 days	Left: Hydronephrosis and hydroureter. Orifice occluded by caked material projecting into cloaca	Left: Chronic pyelonephritis and ureteritis	Right: normal
7 Hen	Right intact orifice	Sacrificed: 43 days	Right: No hydronephrosis or hydroureter. Orifice patent	Right: No infection	Left: normal
8 Hen	Left intact orifice	Sacrificed: 60 days	Left: Hydronephrosis and hydroureter. Orifice patent	Left: Chronic pyelonephritis and ureteritis	Right: normal

TABLE IV.—INCIDENCE OF ASCENDING URINARY TRACT INFECTION AND OBSTRUCTION FOLLOWING URETEROCLOACAL REIMPLANTATION IN THE CHICKEN

	Direct method	Method of intact orifice	Total
Number of implants	13	10	23
Number showing obstructive changes	13	8*	21
Percentage of obstructive changes	100	80	91
Number showing complete occlusion of orifice	8	5	13
Percentage of complete occlusion of orifice	62	50	57
Number showing infection	12	8	20
Percentage of infection	92	80	87

*Chicken 5 of unilateral series showing only mild dilatation of the ureter is not included.

of ascending infection was found in 20 instances, or 87 per cent.

These results are certainly no better than those following uretero-intestinal anastomosis. They furnish proof that:

1. The urinary tract of the chicken is readily susceptible to obstruction and ascending infection. No natural immunity exists, nor do the peculiarities of structure which have been described deter against infection or obstruction.

2. Obstruction of the urinary tract and ascending infection incident to ureterocloacal reimplantation are caused by changes induced at operation, it being evident that the undisturbed relationship of the ureters entering the cloaca is compatible with a normal urinary tract.

3. The critical period of ureterocloacal reimplantation, as in uretero-intestinal anastomosis, is during the first few days after operation when there is a phase of urinary obstruction and acute ascending infection. If this stage is surmounted, a re-establishment of a freer urinary flow and a certain degree of subsidence in renal infection may be anticipated. This factor explains the better results obtained following a two stage operation as compared to those of a one stage bilateral implantation.

The problem of ureterocloacal reimplantation, therefore, presents no particular features apart from those of uretero-intestinal anastomosis. With the results of the ureterocloacal operation equally as poor as those attending uretero-intestinal implantation, one can safely conclude that operative trauma and the opening of tissue spaces in a contaminated field set off the sequence of events which lead to obstruction and ascending infection.

It is important to appreciate the close interrelationship between urinary obstruction and ascending infection. Acute pyelonephritis and ureteritis were present in all the chickens observed within the 5 day postoperative period in which there was complete occlusion of the orifice (9 reimplantations). In the one instance of a patent orifice in this group (No. 1, Table III), a mild pyelitis and ureteritis demonstrated the only inflammatory reaction. Furthermore, in the only three urinary tracts of the entire series which failed to yield evidence of infection following operation (No. 3, Table II; Nos. 5 and 7, Table III) patent orifices were present and little or no dilatation of the ureters and of the renal pelves existed.

SUMMARY

Some reptiles and all birds possess ureters which normally open into a cloaca. Although the cloaca contains numerous pathogenic organisms, spontaneous ascending infection does not occur. The present study was carried out in order to determine whether certain peculiarities of anatomical structure or natural resistance provide these animals with an immunity to infection of the urinary tract. If such were the case, ureterocloacal reimplantation should be an innocuous procedure. This operation was performed, therefore, in 19 chickens. In 4 bilateral and 15 unilateral ureterocloacal reimplantations, making a total of 23 reimplantations in all, obstruction of the urinary tract occurred in 91 per cent and ascending infection in 87 per cent of the cases. These findings indicate the following points:

1. The urinary tract of the chicken is readily susceptible to obstruction and ascending infection.

2. Obstruction of the urinary tract and ascending infection incident to ureterocloacal reimplantation are caused by changes induced at operation.

The problem of ureterocloacal reimplantation, therefore, presents no peculiar features apart from those of uretero-intestinal anastomosis. Operative trauma and the opening of tissue spaces in a contaminated field set off the sequence of events which lead to obstruction and ascending infection. In order to duplicate consistently the normal anatomical arrangement of the ureterocloacal entrance by surgical means, whether in the case of the chicken or of the higher mammals, these complications still remain to be conquered.

We wish to express our appreciation to Dr. Richard A. Peterfy for his assistance in carrying out the experiments reported in this paper.

URETERAL AND RENAL COMPLICATIONS OF CARCINOMA OF THE CERVIX

Their Classification and Management

HENRY L. JAFFE, M.D., JOE V. MEIGS, M.D., F.A.C.S., ROGER C. GRAVES, M.D., F.A.C.S., and CHARLES J. E. KICKHAM, M.D.,
Boston, Massachusetts

THE purpose of this communication is to suggest a method of improving the 5 year end-results in patients with cancer of the cervix by (1) complete urological investigation before institution of radiation therapy and (2) prompt urological management of the ureteral and renal complications which occur either as a direct result of the tumor or as a complication of irradiation.

Within recent years comprehensive studies have been reported from this clinic (4, 5), based upon 390 cases of carcinoma of the cervix, with reference to the urological changes which were shown commonly to accompany this disease. The high incidence of ureteral occlusion was particularly stressed and obstruction of one or both ureters was found in 70 per cent of these cases.

There are also clinical (2, 7, 11), experimental (8, 9), and postmortem (1, 3) studies in the literature which add further emphasis to the importance of the subject.

It is obvious that many complications arise when the tumor encroaches upon or invades one or both ureters. The encroachment results in hydro-ureters, hydronephrosis or pyonephrosis, and even death from uremia because of impaired renal function. It is doubtful in the more advanced cases, whether the 5 year survivals can be increased even with the best form of irradiation and urological treatment. However, a large number of the less advanced cases (Class C—extension to broad ligaments) also die of uremia, either before irradiation has had an opportunity to affect the neoplasm, or after it has been successful in eradicating the malignant disease. It is especially upon this group that our attention is focused. We believe that early recognition and treatment of the upper urinary tract complications should increase the 5 year salvage.

From the Pondville Hospital, Massachusetts Department of Public Health.
Dr. Jaffe is now located in Chicago.

The importance of pre-irradiation urological study in patients with cancer of the uterine cervix has been emphasized in previous communications from this clinic (4, 5). The studies should include (1) a careful history and physical examination, (2) complete laboratory tests of renal function, (3) cystoscopy and ureteral catheterization when possible, and (4) retrograde and intravenous urograms. Only through early investigation can these complications be recognized and treated promptly.

Postirradiation urological study should be carried out when the patient has symptoms and signs referable to the upper urinary tract. These patients may be cured of their malignant disease but they will die of renal insufficiency if their urinary tract complications go unrecognized and untreated.

Prompt treatment of ureteral occlusion will often give the patient marked relief from pain, fever, and the distressing symptoms of renal insufficiency. The general condition of the patient may be a factor in determining the response of the growth to radiation therapy. Drainage of the obstructed kidney and ureter may prevent irreparable damage to these organs and provide the patient with a greater margin of safety should the previously unaffected kidney and ureter later become occluded by disease, infection, or fibrosis.

The type of urological treatment and the time of its application should depend on (1) the age and general condition of the patient; (2) prognosis for cure; and (3) urgency for the relief of distressing symptoms (pain, fever, toxemia). The patient may require only cysto-

scopic treatment with ureteral dilatation. If a nephrostomy should be necessary, the procedure can be carried out with little risk, usually under regional anesthesia. There has been no primary mortality with this operation in our clinic. Postoperative convalescence is usually smooth and often the patient experiences prompt relief.

There are definite indications for neurosurgical relief of pain in advanced cancer of the cervix, but it is essential to exclude the upper urinary tract as the offender. When pain is caused by ureteral occlusion, it is more logical to drain the involved ureter and kidney than to mask the symptoms with opiates, intraspinal alcohol injections, or chordotomy.

UROLOGICAL CLASSIFICATION

The cases showing upper urinary tract complications have been divided into three "urological" groups as follows: Group I—ureteral obstruction before or during treatment; Group II—ureteral obstruction months or years after treatment with no clinical evidence of residual malignant disease; Group III—ureteral obstruction months or years after treatment, with persistent disease. If the ureteral and renal complication is present before or during radiation therapy the case is classified as belonging to Group I. Group II cases include those with ureteral and renal complications developing a number of months or years after the completion of x-ray and radium treatment. These patients have no clinical evidence of residual malignant disease. If the upper urinary tract complication occurs months or years after radiation, but the patient still shows evidence of persistent neoplasm, the case is classified as Group III.

This division of cases is necessary because the indications for urologic management vary with each group. The type of urologic treatment also depends on the prognosis for cure, the life expectancy of the patient, her general state and the urgency for relief of symptoms.

When pre-irradiation urologic study discloses ureteral obstruction (Group I) cystoscopic dilatation of the obstructed ureter should be attempted. If this procedure fails to provide adequate drainage, nephrostomy must then be considered. In selecting a case for nephrostomy the urologist should be guided by the age of the patient (life expectancy) and prognosis for cure. Sometimes nephrostomy is indicated for the relief of pain, fever, or toxemia in spite of advanced malignant disease.

Early urologic treatment improves the general condition of the patient so that she is better able to tolerate the radiation program. Partial ureteral obstruction if present before the onset of irradiation, and if not treated urologically, may become complete by the radiation edema which occurs in the tumor or the ureteral wall itself. If the urinary complication is managed early the patient may survive her irradiation with minimal renal damage.

Immediate urologic management is indicated for patients in Group II. These patients "cured" of their maligant disease may die of renal impairment if the ureteral and renal complications go untreated. Since the obstruction of the ureter has occurred months after radiotherapy, it may be assumed that this is due to postirradiation or replacement fibrosis. It has been possible in many of these cases to drain the obstructed ureters successfully by cystoscopic dilatation at repeated intervals. This group is the most important one because almost all of these patients can be saved if their urological complication is recognized promptly and treated early. Sometimes these patients are not referred back to the clinic but are treated at home by their local physician. He may erroneously assume that they are suffering from recurrent malignant disease and therefore give them sufficient opiate to mask their symptoms until they die of renal insufficiency.

Urologic management is less urgent for patients in Group III because the prognosis for cure is almost nil. Treatment may be necessary for relief of pain, sepsis, or terminal uremic symptoms. A surprising number in this group will live many months following palliative urological treatment in a fair degree of comfort.

The 25 cases with proved ureteral and renal complications reported in this study were found in a group of 70 patients with cancer of the cervix treated at the Pondville Hos-

TABLE I.—INCIDENCE OF UPPER URINARY TRACT COMPLICATIONS IN 70 TREATED CASES OF CANCER OF THE CERVIX

	Number	Per cent	Clinical class A	B	C	D
Total cases	70	100	5	3	45	17
Proved ureteral obstruction	25	35.7	0	0	19	6

pital and followed for 5 or more years (10). The incidence of this complication therefore is 35.7 per cent for the group (Table I). There were no clinical class A or B cases with proved ureteral obstruction. This fact is important because it may indicate that the obstruction is not due to radiation effect on the ureteral wall. It may be due to a tumor tissue edema during treatment or a "replacement" fibrosis after treatment in those cases in which the disease extends out into the broad ligaments. There were 19 C cases and 6 D cases. Thirteen cases, or 52 per cent, of the group showing this complication, developed upper urinary tract obstruction before the onset of treatment (Group I). Two patients, or 8 per cent, first showed ureteral occlusion months after the end of their treatment and had no clinical evidence of residual cancer (Group II). Ten patients, or 40 per cent, had upper urinary tract complications months after treatment, but still had residual disease (Group III). Of the total number with urinary complications only 5 received urologic treatment. Two of these patients are alive and well after a period of 5 years and 3 of them are dead. Both of the living patients developed signs and symptoms of ureteral occlusion many months after the completion of their radiation therapy and presented no evidence of residual malignant disease (Group II—Table II).

TABLE III.—PROVED URETERAL OBSTRUCTION—24 CASES

Group	No. cases	Per cent	G. U. treatment D	L	No G. U. treatment L	D	Average duration of life—months Treatment	No treatment
I	13	52	2	0	2	11	0	11	41	12
II	2	8	2	2	0	0	0	0	65	..
III	10	40	1	0	1	9	0	9	20	20
Totals	25	100	5	2	3	20	0	20	42	16

TABLE II.—PROVED URETERAL OBSTRUCTION—DISTRIBUTION ACCORDING TO GROUP AND EXTENT OF DISEASE

Group	Number	Per cent	Clinical class A	B	C	D	Living 5 years
I.	13	52	0	0	8	5	0
II.	2	8	0	0	2	0	2
III.	10	40	0	0	9	1	0

ANALYSIS OF CASES WITH URETERAL AND RENAL COMPLICATIONS

The 25 cases of proved ureteral obstruction, divided according to their respective urologic groups, are further analyzed in Table III.

Group I. Thirteen, or 52 per cent of 25 patients, showed *ureteral obstruction before or during x-ray and radium treatment.* There were no Class A or B cases. Eight patients were in Class C, and 5 in Class D.

Study. All but 1 of these 13 patients complained of pain varying from 1 to 14 months' duration, or an average of 4 months, before the onset of treatment. The character of the pain varied from a dull ache to a sharp lancinating type, the former being the more common. It occurred either in one or both flanks, and if unilateral it corresponded to the side of the involved ureter or kidney. Occasionally the pain radiated down to the crest of the ilium or to the hip on the involved side. Sometimes it had a "sciatic" distribution down the posterior aspect of the thigh to the knee. Occasionally the patient stated that the pain was referred to the groin or vulva. A number of patients complained of "low abdominal cramps" and others of "low back pain." One patient had severe pain in the right lower quadrant and had an appendectomy before admission. This patient continued to have the same type of discomfort after her operation and subsequently proved to have a right hydro-ureter and right hydronephrosis complicating a cervical cancer. In the majority the location of the pain and the involvement of the ureter corresponded to the side which by clinical examination showed broad ligament involvement. Postmortem examination revealed the involved ureter to be on the same side as the pain.

Blood chemistry estimation of total nonprotein nitrogen retention showed the level to

remain within normal limits in all but 1 case until the late stages of renal destruction. In 1 patient it rose to 250 milligrams per 100 cubic centimeters. The routine 2 hour test of renal function with phenolsulfonphthalein was a much better test for early renal insufficiency. Intravenous pyelography was useful in those cases in which ureteral catheterization proved impossible. Retrograde pyelography was more accurate in determining the *degree* of hydronephrosis. Obstruction within the ureter was met usually at a point 4 to 6 centimeters above the ureteral orifice.

Two patients in this group were examined postmortem. One had a blocked ureter on the left side with hydro-ureter and hydronephrosis, and a right pyelitis and ureteritis. The other showed both ureters blocked by disease.

Treatment. Many of the patients included in this study entered the hospital before complete urological investigation and prompt management became a routine procedure. As a consequence, 4 patients in Group I were not seen by the Urological Service. One patient who was investigated refused nephrectomy. One patient had a ureterostomy performed after the first day of treatment because of chills, fever, and renal pain. Radiation treatment was resumed 10 days after operation without subsequent exacerbation of symptoms. She was sent home with a ureterostomy tube in place. She was free of disease clinically and did well for 1 year and 7 months until her local physician removed the ureterostomy tube because he thought she could get along without it. She soon complained of costovertebral pain and died 4 months later with evidence of terminal uremia. One patient treated by ureteral dilatation lived 5 years and 3 months, and died of recurrent disease with ureteral occlusion. One patient who had no urological investigation was seen by the Neurosurgical Service, and had four alcohol injections and two chordotomies in an attempt to relieve her pain. Postmortem study showed bilateral renal and ureteral involvement (see case report). Five other patients were either studied incompletely from the urologic standpoint or had treatment deferred until renal damage was beyond recovery.

The average duration of life in the group that had no urologic treatment was 12 months, while the group which had urologic therapy lived an average duration of 41 months from the onset of the treatment.

Group II. Two patients, or 8 per cent, showed *ureteral obstruction after completion of treatment with no clinical evidence of residual disease.* Both of these patients were in clinical Class C.

Study. One patient complained of pain in both flanks 21 months after radiation therapy. The other had pain in the left flank radiating toward the groin 7 months after treatment. Because there were only 2 patients in this group we cannot draw definite conclusions. However, it is interesting to note that the appearance of symptoms averaged 14 months for Group II as compared to 4 months for those patients in Group I. The delayed appearance of symptoms may be due to the slowly constricting scar tissue which forms about the lower ureter. The cicatrization may be a direct result of irradiation or a "replacement" fibrosis. Again the pain and ureteral occlusion occurred on the side that also showed clinical broad ligament involvement.

Blood chemistry determinations were not significant. One patient had a normal bilateral intravenous pyelogram but demonstrated bilateral hydro-ureters and hydronephroses on retrograde pyelography. Retrograde pyelography showed that the other patient had definite evidence of ureteral stricture on one side.

Treatment. Both patients had prompt urologic treatment consisting of ureteral dilatation. This procedure was repeated at successive intervals and proved to be sufficient in each case.

The value of prompt management is evident as both patients are alive and well, one 5 years and 8 months, and the other 6 years after treatment.

Group III. Ten patients, or 40 per cent, showed evidence of *ureteral obstruction developing after completion of treatment and with positive evidence of residual disease.* Nine had evidence of extension of the disease into one or both broad ligaments (Class C). One patient had remote metastases (Class D).

Study. All patients in this group complained of pain. The duration varied from 5 months to 17 months, the average being 9½ months. In all but 2 instances the location of the pain corresponded to the side of the ureteral pathology and likewise to the side that had broad ligament extension.

A review of the findings shows that intravenous and retrograde pyelograms were more dependable tests of renal damage than the blood chemistry estimation of total non-protein nitrogen.

Treatment. Only 1 patient in this group received urologic treatment. This consisted of ureteral dilatation on one occasion. She lived 1 year and 8 months and died of uremia. Two patients required such large doses of opiate for relief of pain that they subsequently became morphine addicts.

The average duration of life in this group was 20 months. There were 5 postmortem studies and all proved that death was due to renal impairment from obstructed ureters. In a number of these patients there was considerable fibrosis noted about the ureters.

TREATMENT BASED ON COMPLETE UROLOGIC EXAMINATION

It is now routine practice in this clinic to carry out complete urologic investigation before treatment is given for carcinoma of the uterine cervix. A careful history is extremely important to detect symptoms which may suggest ureteral occlusion.

Ureteral stricture produces a nagging type of discomfort or sharp pain at or near the site of occlusion or in the renal area on the affected side. The pain was nearly always present on the same side as the broad ligament extension of the disease. Radiation of pain occurred upward toward the kidney, laterally into the hip or groin, or posteriorly into the thigh or leg. The pain was either intermittent or constant. When pain occurs as a symptom in cancer of the uterine cervix it may be due to extension of the disease or may be caused by a complication of the treatment. Skeletal involvement can usually be proved by roentgen examination. Stenosis of the cervical canal with associated pyometrium may be determined by probing the uterine canal. Pelvic peritonitis if present presents the usual signs and symptoms commonly associated with any peritonitis. One may therefore in a differential diagnosis strongly suspect a stricture of the ureter if the other causes of pain as outlined above are excluded.

It is not the purpose of this paper to prove or disprove the theory that ureters may be occluded as a result of radiation therapy alone. A number of authors have reported their clinical (2, 4, 5, 7, 11) and laboratory (8, 9) experience which points to the fact that post-irradiation fibrosis does occur. We have observed ureteral occlusion following divided doses of x-ray alone (400 r per day to one of four pelvic portals, 8 by 10 centimeters each, alternating fields daily, two anterior and two posterior fields, 50 centimeters focal skin distance, ½ millimeter copper and 1 millimeter aluminum filter. Total of 1200 r to each of the anterior portals and 800 r to each of the posterior portals, grand total of 4000 r in 10 treatments). This obstruction probaly resulted from radiation edema. We have also seen ureteral obstruction clinically and at postmortem examination (12) many months after treatment, with and without the presence of gross residual neoplasm. This obstruction in some instances seemed to be due to fibrosis. Whether it is a "replacement" fibrosis or an actual radiation fibrosis is difficult to state. Its less frequent occurrence, clinically, in the A and B cases would argue against the latter.

Complete physical examination is made especially with regard to renal enlargement or tenderness. Graves and Militzer have emphasized the fact that advanced kidney damage may occur without local signs and symptoms. Therefore, one must study the patient still further to complete the urological examination.

Blood nitrogen studies are carried out, but cannot be relied upon for early evidence of impaired renal function. In our series, the elevated non-protein nitrogen was usually a terminal finding. The renal function test with phthalein was a much better test for early renal insufficiency. Routine cystoscopy and ureteral catheterization give important information concerning the presence or absence of bladder invasion and especially the degree

of patency of the ureters. The divided test of renal function with intravenous phthalein is employed, and when the ureters are not identified or when catheters cannot be passed, indigocarmine is used.

Retrograde and intravenous pyelograms complete the study of the upper urinary tract. It is important to remember that patients with relatively normal intravenous pyelograms may show definite obstructive changes in the ureters and kidney, by retrograde pyelography.

It is important to relieve the obstructed ureter at once, preferably before radiation therapy is started. This should be done by ureteral dilatation if possible. Occasionally the patient may be treated with an indwelling ureteral catheter, following gentle dilatation. If the degree of hydro-ureter and hydronephrosis is great, nephrostomy must be considered. This of course is limited to those patients who still show residual function in the affected kidney. If the patient is relieved of her disease and ureteral patency is reestablished after treatment, it is still possible to remove the nephrostomy tube and allow the fistula to close spontaneously.

Nephrectomy is reserved for the infected and functionless kidney which is causing chills, fever, and toxemia in cases in which the condition of the patient and the state of the other kidney warrant this operation.

When the prognosis is questionable or positively hopeless (advanced or Class D cases), treatment should be symptomatic and palliative only.

Patients who present themselves months or years after radiation treatment with the complaint of backache, pain in the lower abdomen, hip, groin, vulva, or leg, showing no evidence of residual neoplastic disease (Group II) require careful search for ureteral obstruction. If a positive diagnosis is established, ureteral dilatation may be attempted when the affected kidney still retains its function. If this fails the patient should have a nephrostomy or nephrectomy. Should obstruction be complete and the kidney functionless and silent, nothing need be done, except careful observation at relatively frequent intervals with reference to the other kidney. The patient should be instructed always to return immediately on the occasion of pain, chills, or fever. These symptoms may signal the onset of infection in the previously unaffected kidney. Immediate measures should be taken to prevent complete anuria and uremia. It is sometimes necessary to do a nephrostomy upon the previously unaffected but now infected kidney in order to save the patient's life. On the other hand, the previously silent kidney may be the cause of the patient's symptoms, and if so nephrectomy should be performed.

Those patients showing ureteral stricture months or years following radiation but who still have evidence of recurrent or residual disease (Group III) may require palliative treatment to the involved upper urinary tract. Usually it is not possible to relieve the ureteral obstruction by dilatation from below, because the persisting disease does not permit dilatation. More radical measures, such as nephrostomy or nephrectomy, should be limited to those patients showing evidence of uremia or severe toxemia due to upper urinary tract infection.

CONCLUSIONS

1. The importance of urologic investigation before treating cancer of the cervix by radiation is re-emphasized.

2. A classification of the cases according to the development of ureteral obstruction before, during, or after treatment, with or without the presence of local disease, is presented.

3. The need for prompt urologic management is suggested, once the diagnosis has been established. The type of urologic treatment selected should depend on the state of the local disease and the general condition of the patient.

4. An analysis of a group of 70 cases followed 5 years after treatment shows an incidence of 35.7 per cent of proved ureteral obstruction. Those patients having prompt, adequate urologic treatment showed good end-results. Those patients not treated died from uremia.

5. Improvement of 5 year end-results may be expected if this large group showing ureteral and renal complications is treated promptly. If death from renal impairment is prevented, a larger percentage of those developing ure-

teral occlusion before or during radiation therapy may live long enough to obtain the maximum effect of their treatment. The Group II cases should all do well if the complication is recognized and treated early. Life may be prolonged in the Group III cases and these patients may be spared the distressing symptoms of terminal uremia.

6. Carcinoma of the cervix is a "combined system disease," requiring the attention of the gynecologist, urologist, and radiologist.

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MALIGNANT TUMORS OF THE THYROID GLAND

Report of 200 Consecutive Cases

U. V. PORTMANN, M.D., Cleveland, Ohio

THIS study of malignant tumors of the thyroid gland is based upon 200 consecutive cases in which clinical and microscopic diagnoses were made by Dr. George Crile and associates of the Cleveland Clinic Foundation between 1922 and 1933, inclusive. This period of time was selected because deep roentgen therapy was instituted at the clinic in 1922 before which time the treatment was quite empirical or definitely experimental. In addition, a 5 year period has elapsed since 1933. This series includes approximately one-half of the cases of malignant tumors of the thyroid observed prior to 1922 and after 1933. All the cases have been studied from the standpoint of pathology by Dr. Allen Graham.

The series was first classified on the basis of the different types of histopathology according to the plan originally advocated by Dr. Graham in 1925 and outlined in Table I.

TABLE I.—HISTOLOGICAL CLASSIFICATION OF MALIGNANT TUMORS OF THYROID

I. Carcinomas originating in pre-existing adenomas
   - A. Malignant adenomas
   - B. Papillary carcinomas

II. Carcinomas without evidence of having originated in pre-existing adenomas
   - A. Adenocarcinomas
   - B. Scirrhous carcinomas

III. Mixed type
   Carcinoma-sarcoma

IV. Sarcomas
   - A. Lymphosarcoma
   - B. Fibrosarcoma
   - C. Other types

The tumors to which Dr. Graham applied the name "malignant" adenomas possess no characteristic histology. They originate in pre-existing adenomas; therefore they present the histology of fetal, intermediate, or mixed colloid adenomatous structure and any one, two, or even all these transitional types may be found in a single tumor; in fact, it is seldom that only one is found. Therefore, a malignant adenoma may present the morphological characteristic of any one or more of the forms: adenocarcinoma, medullary carcinoma, scirrhous carcinoma, papillary carcinoma (not papillary cystadenoma), or carcinoma resembling sarcoma. Because of this diversified variability in the structure of these tumors, it is sometimes difficult to differentiate or classify them only on a histological basis; therefore it is necessary to study the gland as a whole, its probable involutional changes, the type of structure of the pre-existing adenoma in which neoplasia began, as well as its duration, rate of growth, and stroma reaction. The outstanding characteristic of malignant adenomas is the invasion of the blood vessels in which there may be thrombi or intravascular polypi with the same morphological characteristics as are found in the parent tumor. This invasion of the blood vessels does not occur with other types of thyroid tumors which extend into the lymphatics.

The "papillary carcinomas" are primarily localized, encapsulated neoplasms with characteristic papillary morphology. Sometimes cells in papillary tumors may break through the thin stroma at the base of the acini and invade and extend into surrounding structures whereupon the neoplasms may be considered malignant. The lateral labyrinth or aberrant thyroid tumors with papillary structure, which may be found outside or within the thyroid capsule, are not and should not be included among malignant tumors of the thyroid *per se*. They are seldom malignant and they do not recur if completely removed, but others may develop in the embryonic tract or lateral labyrinth from which the primary growth originated.

From the Cleveland Clinic.

The adenocarcinomas not known to originate in pre-existing adenomas, *adenocarcinomas not in adenoma*, apparently begin in acinar epithelium. The tumor is found as a small, definitely localized, although non-encapsulated growth, of very low grade malignancy. The subsequent course or development of this neoplasm is unknown. They are discovered only by the pathologist and produce no clinical signs.

The "scirrhous carcinomas" have the same origin and histological characteristics as scirrhous tumors which are found in other glandular organs. Fibrous tissue predominates and the neoplastic epithelial cells occur in masses or strands. It cannot be proved that these tumors begin in pre-existing adenomas although possibly they may do so. They are not encapsulated and they invade and surround neighboring structures quite rapidly by permeation through the lymphatics.

The "carcinoma-sarcomas," those tumors with complex morphology, contain both epithelial and mesothelial malignant elements. They invade the lymphatics, and their clinical course is similar to that of scirrhous carcinoma.

Sarcomas of the thyroid are comparatively rare. In many reports in the literature they apparently have been confused often with malignant adenomas and vice versa. Some pathologists do not agree that sarcomas occur in the thyroid and call them round cell carcinomas. Yet there is no reason why the abundant mesothelial elements in the thyroid, especially the lymphoid tissue and stroma, might not occasionally undergo malignant degeneration to produce sarcomas. The "lymphosarcomas" and "fibrosarcomas" of the thyroid have the same histopathology as the same types of tumors found in other locations.

In addition to the pathological classification of the malignant tumors these cases have been grouped also according to the extent of disease found in each clinically, at operation, or by the pathologist's examination. Such a grouping is advisable in order to make equitable statistical comparisons between different methods of treatment. In a great many reports in the literature about the results obtained by different therapeutic procedures for different types of malignant neoplasms, and in which all cases are included in one category, whether in early or late stages, it is often obvious that there was a disproportion between the early and advanced cases in the series used for comparison. This is especially apparent when the results of operation alone and of radiological procedures are compared, because it is usually when the disease is more advanced that irradiation is given. Statistical comparisons based upon inequalities in the types of cases treated by different methods lead to erroneous conclusions. Therefore, in this study the results will be shown on the basis of the different histological types of tumors found and also on the basis of a plan for grouping cases according to the extent of disease. The plan which will be employed in this study is based upon the criteria presented in Table II.

TABLE II.—A PLAN FOR GROUPING MALIGNANT TUMORS OF THYROID ACCORDING TO EXTENT OF DISEASE

Group I. Cases without clinical evidence of malignant tumor which was discovered only after microscopic examination and the tumor was only a few millimeters in diameter.

Group II. Cases without clinical evidence of malignant tumor, or its presence was suspected only on the basis of a history of rapid enlargement of the thyroid gland, or discovered at operation and the growth was still localized within the thyroid capsule.

Group III. Cases with clinical evidence of malignant tumor which had invaded or extended outside of the thyroid capsule to neighboring or distant structures.

The series of 200 consecutive cases, classified and grouped according to this plan and also according to histopathology is shown in Table III. The primary cases are those in which no treatment was given prior to admission to the clinic. The recurrent cases are those in which local recurrence followed operations prior to admission. The cases having no treatment comprise those patients who presented themselves without having had any previous treatment and were in such advanced stages of the disease that treatment was not justifiable, and also a few patients who refused treatment at the clinic after a clinical diagnosis had been made and treatment advised. The cases listed as "unclassified" are

TABLE III.—ALL CASES CLASSIFIED AND GROUPED

Pathological classification	Primary cases					Recurrent cases	Total cases	Per cent of all cases
	G I	G II	G III	Total	Per cent			
Malignant adenoma	2	19	45	66	53.2	7	73	54.8
Papillary carcinoma	7	11	3	21	17.0	1	22	16.5
Adenocarcinoma not in adenoma	19			19	15.3		19	14.3
Scirrhous carcinoma			3	3			3	
Carcinoma-sarcoma			1	1			1	
Lymphosarcoma			11	11	9.0		11	8.2
Fibrosarcoma			2	2		1	3	
Myxosarcoma			1	1			1	
Classification unknown	28	30	66	124	62.0	9	133	65.0
Unclassifiable			14	14		1	15	10.1
Classifiable			80	138	69.0	10	148	74.0
Unknown pathology			46	46	25.0	6	52	26.0
Total Cases	28	30	126	184		16	200	

those with positive microscopic evidence of a malignant tumor but the type could not definitely be determined. No microscopic examination was done in the cases listed as "unknown pathology" as these were in such advanced stages that biopsy even to appease scientific curiosity was not justifiable.

The incidence of occurrence of different tumors is shown in Table III. This shows that of a total of 133 primary and 9 recurrent cases, that could be classified on the basis of histology, there were 73 malignant adenomas, or 54.8 per cent, which is more than one-half of the 148 classifiable tumors. The next largest type are the papillary carcinomas, or 16.5 per cent. Thus a total of 95 tumors or over 70 per cent in the series can be proved to have originated in pre-existing adenomas. This incidence supports Dr. Graham's contention that a large percentage of all malignant tumors of the thyroid originate in pre-existing adenomas. The third largest group is made up of the adenocarcinomas not in adenomas which are histologically malignant but clinically benign. The lymphosarcomas were not uncommon, 8.2 per cent, but only a few of the scirrhous carcinomas, carcinoma-sarcoma, and other rare types were met.

According to the plan adopted for grouping (Table III), 28 of the total 184 primary cases fell into Group I, or 15.2 per cent, 30 fell into Group II, or 16.3 per cent, and 126 fell into Group III, or 68.5 per cent. This indicates that two-thirds of the patients with malignant tumors of the thyroid were in advanced stages of the disease when first seen and, as will be shown, were incurable by operation alone.

The early or Group I cases comprise only 2 malignant adenomas, the remainder being papillary carcinomas and adenocarcinomas not in adenomas, which were not even suspected by clinical examination or at operation performed primarily for other thyroid disturbances, but the malignant tumor was subsequently discovered by the pathologist.

Group II, composed of moderately early cases, is made up exclusively of malignant adenomas and papillary carcinomas which apparently had not yet invaded to any great extent outside the primary adenoma and not at all outside the thyroid capsule as observed clinically, at operation, or after pathological examination.

Group III comprises the most advanced cases with tumors invading outside the thyroid capsule. Forty-five, or 68.2 per cent of this group, were malignant adenomas. All the other types of tumors, except the adenocarcinoma not in adenoma, fall into this advanced group. All the cases in which no microscopic examinations were made because of the extent of the disease, of course, fall into Group III.

TABLE IV.—ALL CASES IN GROUPS ACCORDING TO TREATMENT

Treatment	G I	G II	G III	Total	Per cent treated	Recurrent cases	Total cases	Per cent of all cases
Operation only	17	8	21	46	30.0	2	48	29.1
Operation + x-ray	11	22	41	74	47.4	5	79	46.8
X-ray only			30	30	25.7	4	34	20.2
Operation + radium			3	3		1	4	
Radium only			3	3			3	
Total treated	28	30	98	156	78.0	12	168	84.0
No treatment			28	28	15.2	4	32	16.0
Total cases	28	30	126	184	94.0	16	200	

Table IV shows the different methods of treatment employed for the cases in each group. In Group I, operation only was performed in 17 of the total 46 primary cases, or 37 per cent. Of the 46 cases in which operation was the only treatment, 25, or over 50 per cent, were in the early and moderately early Groups I and II while 29, or 63 per cent, were in the less favorable Groups II and III. On the other hand, of the total 74 cases which had roentgenotherapy after operation only 11, or 14.8 per cent, were in Group I and 33, or 43 per cent, in the early and moderately early Groups I and II but 63, or 85 per cent, were in the less favorable Groups II and III. Therefore, roentgenotherapy was given after operation in this series in a larger proportion of advanced cases than the proportion in which operation was the only treatment. This supports the previous statement to the effect that a large proportion of cases irradiated are in advanced stages of the disease, and this fact should be taken into consideration in passing judgment about the comparative efficacy of these therapeutic procedures.

In this study the patients treated by procedures other than operation and postoperative roentgenotherapy, those not treated, and recurrent cases are not given consideration except that they are taken into account in the totals determining the pathological classification or the groupings.

The tables dealing with the mortality statistics of the primary treated cases show:

1. The "operative mortality" which includes all patients who died in the hospital immediately following any operative procedures, whether an attempt was made to remove all or only a portion of the thyroid gland, or whether only palliative operations such as decompression or biopsies were done. However, when only biopsies or palliative operations were done and the patient survived and irradiation followed, the minor operative procedure is not considered as operation followed by irradiation but these are included in the series having roentgenotherapy only. The operative mortality cases are included among the known dead of cancer in the first year period following.

2. The number of "known living" is reduced in succeeding years by the total number of cases "lost trace," "dead not of cancer," and "known dead of cancer." Those known to have lived free from cancer but died not of cancer after 5 years are included in the known living after 5 years.

3. The "lost trace" are those in which the outcome was not known, and the number lost in each yearly period is added to the total of the preceding year.

4. When the death of a patient was proved to be caused by a disease other than the malignant neoplasm, it is recorded shown as "dead not of cancer" and the number is added to the total of the preceding years.

5. The "known dead" include all not proved to have been dead not of cancer, and the number of deaths in any yearly period is added to the total of the preceding year. It should be noted that the number of "lost trace" and "dead not of cancer" are accounted for in each yearly period except that the cases dead not of cancer after 5 or more years of survival are taken as known living. Every primary case in the series is accounted for.

TABLE V.—SUMMARY OF RESULTS IN ALL PRIMARY CASES ACCORDING TO CLASSIFICATION

Pathological classification	Total cases	Operative mortality	No. of known living					
			1 yr.	2 yr.	3 yr.	4 yr.	5 yr.	5+ yr.
Malignant adenoma	73	10	37	32	27	22	19	10
Papillary carcinoma	22	0	19	17	15	14	13	12
Adenocarcinoma not adenoma	19	0	16	15	14	14	14	13
Scirrhous carcinoma	3	2	0	0	0	0	0	0
Carcinoma-sarcoma	1	0	1	0	0	0	0	0
Lymphosarcoma	11	1	3	3	3	3	3	3
Fibrosarcoma	3	0	1	1	1	1	1	1
Myxosarcoma	1	0	1	1	0	0	0	0
Unclassified	15	3	5	2	2	2	2	2
Unknown pathology	52	1	9	5	2	1	1	1
Total	200	17	92	76	64	57	53	41
Lost trace	34		20	23	27	31	33	34
Dead not of carcinoma	8		2	3	4	5	5	8
Dead of carcinoma	117	17	86	98	105	107	109	117

The results obtained in all the different types of tumors by all therapeutic procedures are shown in Table V. Although it would appear that the malignant adenomas present a fairly favorable prognosis, it should be recalled that only about one-third of them were in the early Groups I and II. However, as will be shown later (Table VI), not one of the patients with this type of tumor in the advanced stages (Group III) having operation alone, was known to be living at the end of one year. The papillary carcinomas are shown to have a considerably better prognosis since over one-half of these patients lived 5 or more years but also only 2 of 22 cases with papillary carcinomas were placed in the unfavorable advanced Group III. The tiny adenocarcinomas not in adenomas give the very best prognosis. All of them fall into the earliest Group I and not one of these neoplasms was fatal. The lymphosarcomas also have a fair prognosis but only because they proved to be radiosensitive, since only those patients who were irradiated survived. All the other types of tumors have an unfavorable prognosis except possibly some fibrosarcomas which tend to remain localized for considerable time and may be completely excised.

It is unnecessary to present tables showing the results from operation only and operation with postoperative roentgenotherapy for Group I and Group II cases because it was found that there was very little difference in the results obtained by either therapeutic procedure for these more favorable groups. It was found that postoperative roentgenotherapy gave no better results in Group I cases than operation alone. This might be expected because the operation removed completely all the localized tumors in these early cases. However, in Group II it was found that a slightly higher proportion of patients survived in each yearly period if postoperative roentgenotherapy was given than if operation was the only treatment although, after the 5 year period, the proportion of known living was almost the same. The known dead of cancer in the irradiated series was proportionately somewhat less than in the nonirradiated. This would appear to indicate that postoperative roentgenotherapy was beneficial in prolonging the lives of some Group II patients.

Table VI shows that no patient with advanced disease in Group III survived even one year following operation alone, no matter what type of tumor was present. There was an exceptionally high operative mortality, over 70 per cent, as some operations were decompressions done only for palliation.

TABLE VI.—GROUP III. RESULTS OF OPERATION ALONE IN PRIMARY CLASSIFIED CASES

Pathological classification	Total cases	Operative mortality	No. of known living					
			1 yr.	2 yr.	3 yr.	4 yr.	5 yr.	5+ yr.
Malignant adenoma	12	8	0	0	0	0	0	0
Scirrhous carcinoma	2	2	0	0	0	0	0	0
Lymphosarcoma	2	1	0	0	0	0	0	0
Unclassified	4	3	0	0	0	0	0	0
Unknown pathology	1	1	0	0	0	0	0	0
Total	21	15	0	0	0	0	0	0
Lost trace	0		0	0	0	0	0	0
Dead not of carcinoma	1		1	1	1	1	1	1
Known dead of carcinoma	20	15	20	20	20	20	20	20

TABLE VII.—GROUP III. RESULTS OF OPERATION AND POSTOPERATIVE ROENTGENOTHERAPY IN PRIMARY CASES

Pathological classification	Total cases	Operative mortality	No. of known living					
			1 yr.	2 yr.	3 yr.	4 yr.	5 yr.	5+ yr.
Malignant adenoma	24	0	14	11	8	5	4	1
Papillary carcinoma	2	0	2	1	1	1	1	0
Carcinoma-sarcoma	1	0	1	0	0	0	0	0
Lymphosarcoma	7	0	3	3	3	3	3	3
Fibrosarcoma	2	0	1	1	1	1	1	1
Unclassified	5	0	3	1	1	1	1	1
Total	41	0	24	17	14	11	10	6
Lost trace	2		1	1	1	2	2	2
Dead not of carcinoma	3		0	1	1	1	1	1
Dead of carcinoma	32	0	16	22	25	27	28	32

However, Table VII shows that some patients in the same category, Group III, with advanced disease survived as long as 5 years after treatment by roentgenotherapy following operation even though the types of tumor present have been considered as the least favorable. Six of 41 of these patients, or 14.6 per cent, are known to have survived more than 5 years, and 10, or 25 per cent, to the end of the fifth year. It is shown that, although the number of known dead increased year by year after the first year, there was a fair proportion known to be alive in each yearly period.

These observations suggest that when a clinical diagnosis of a malignant tumor of the thyroid can be made and there is evidence that it has extended or invaded outside the thyroid capsule, radical operative procedures are not indicated because all of the neoplastic tissue cannot be removed. Instead the patient should be treated primarily by irradiation, either radium, roentgenotherapy, or both according to indications.

A summary of the results obtained by different methods of treatment for different groups of cases is further illustrated by Table VIII in which it should be noted that no deductions are made for the "lost trace" or "dead not of cancer" up to 5 years. This tabulation also shows that 40 of 156, or 25.6 per cent of all primary treated cases, were known to be surviving after 5 years and 116, or 55.8 per cent, were known dead, the others, 18.6 per cent, having been lost or dead not of cancer (14.1 per cent). If the 22 lost cases, and the 4 dead not of cancer prior to the 5 year period are discarded, then 130 of a total

TABLE VIII.—RESULTS OF TREATMENT IN ALL PRIMARY CASES

Group	Treatment	Total cases	Operative mortality	No. of known living					
				1 yr.	2 yr.	3 yr.	4 yr.	5 yr.	5+ yr.
I	Operation only	17	0	14	12	12	12	12	12
	Operation + x-ray	11	0	10	10	8	8	7	7
	Total	28	0	24	22	20	20	19	19
II	Operation only	8	1	6	6	5	4	4	4
	Operation + x-ray	22	0	20	20	17	15	13	12
	Total	30	1	26	26	22	19	17	15
III	Operation only	21	15	0	0	0	0	0	0
	Operation + x-ray	41	0	24	17	14	11	10	6
	X-ray only	29	0	7	5	4	4	4	2
	Operation + radium	3	0	1	1	0	0	0	0
	Radium only	4	0	1	1	1	0	0	0
	Total	98	15	33	24	19	15	14	6
All primary cases		156	16	83	72	61	54	50	40
Lost trace		22	..	10	13	15	20	22	22
Dead not of carcinoma		7	..	2	3	4	4	4	..
Dead of carcinoma		87	16	61	68	76	78	80	87
Total		116	16	73	84	95	102	106	116

of 156 primary treated cases remain and on the basis of this method sometimes employed in compiling statistics 30.3 per cent of patients are known to have lived more than 5 years as a result of all methods of treatment.

The operative procedures employed with the object of curing either unsuspected or clinically diagnosable malignant tumors of the thyroid gland in this series were complete or partial thyroidectomies or lobectomies. The palliative operations were partial thyroidectomies or decompressions to remove part of the diseased gland or tracheotomies primarily for the relief of respiratory distress or biopsies.

The roentgenotherapy was administered according to the method employed 5 or more years ago. The right and left thyroid areas, the posterior cervical, and the anterior and posterior mediastinum were usually irradiated, the trachea and larynx being protected. Each field received one skin tolerance dose of 800 r's in one or 2 treatments using 200 kilovolts and 0.75 millimeters of copper with 1 millimeter of aluminum for filter (h.v.l. 1.0 millimeter copper) at 50 millimeters distance. Thus the entire course of treatment was given within 5 to 10 days. Approximately half the patients received only one course of treatment because of the fear of severe skin reactions; others were given 2 courses and a few received 3 or more courses at widely spaced intervals of many months according to indications.

Radiologists will appreciate that this method was inadequate as compared with more recently developed and more efficacious procedures. The antiquated method employed for administering roentgenotherapy in this series of cases has been discarded. At present the same physical and mechanical factors are being employed but the same anatomical fields are each given from 200 to 250 r's on alternating days so that the entire course of treatment is prolonged to 3 or more weeks and the total dosage is about 3 or more times as great as previously. The immediate results noted by the newer method appear far superior.

CONCLUSIONS

1. The incidence of histological types of malignant tumors of the thyroid gland is shown in a series of 200 consecutive cases of which 74 per cent were classifiable.

2. The prognosis for each histological type by different methods of treatment has been shown and a comparison made between operation alone and operation followed by roentgenotherapy.

3. A plan is suggested for the grouping of cases according to the extent of disease regardless of histological types for statistical studies or comparisons of the results of different methods of treatment.

4. According to the grouping plan suggested, about 15 per cent of cases fall into Group I and present no clinical manifestations. They are discovered only by the pathologist and are curable by operation alone. Irradiation by any method is of no benefit.

5. Approximately 16 per cent of cases fall into an intermediate Group II without evidence of extension outside the thyroid capsule. Of this group about 50 per cent are curable by operation alone, and postoperative roentgenotherapy seems to have been of benefit because the lives of some patients were prolonged.

6. About two-thirds of all patients are in advanced stages of disease and fall into Group III, the presence of the malignant tumor being manifest clinically. Of these, none survived one year by operation alone, but a few survived as long as 5 years following postoperative roentgenotherapy.

7. The statistical study indicates that only palliative operations are indicated for advanced and clinically diagnosable malignant tumors of the thyroid gland and that irradiation by roentgenotherapy alone or in combination with radium treatment according to individual indications should be the only therapeutic procedures for a large proportion of this group.

8. The advances made in irradiation procedures since this series of cases was treated indicate that even better results may be anticipated in the future.

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CLINICAL SURGERY

FROM THE AMSTERDAM EYE CLINIC

PLASTIC RESTORATION OF A DEFORMITY CAUSED BY COMPLETE EXENTERATION OF THE ORBIT

A. HAGEDOORN, M.D., Amsterdam, Holland

EXENTERATION of the orbit for a tumor is followed by a deformity which may be corrected by a plastic operation. The method used in a recent case involved a four-stage operation wherein by means of free and pedunculated fat transplants the orbit was prepared for an Esser-Wheeler operation.

The exenteration had been complete and only the skin of the eyelids was preserved and served as a partial covering of the walls of the orbit. Granulation tissue lined the apex of the orbit when the patient was first observed, but finally became covered by epithelium (Fig. 1).

An incision is made parallel with and a few millimeters beneath the inferior margin of the orbit at the first operation (Fig. 2). The skin over the inferior orbital margin is dissected free and a large pocket made by separating the skin and a thin layer of subcutaneous tissue in the infra-orbital region from the underlying tissue. This pocket is filled with a free transplant of fat and connective tissue which is obtained from the radial side of the thigh over the fascia lata. The sutures have been introduced previously so that the wound can be closed accurately and immediately after the implantation of the fat. Fat from the region of the fascia lata is selected because it contains more connective tissue than the fat from the buttocks or the abdominal wall. The quality of the transplanted fat and the ideal nutrition of the transplant produce very little shrinkage.

Figure 3 shows the first step of the second operation. The scar of the first operation is circumscribed and the epithelial edges are removed. The skin is dissected downward, medially and laterally, and upward across the floor of the orbit to the horizontal ridge at the apex of the orbit. The skin of the upper eyelid is separated from the orbital wall over a short distance. The edge of the transplanted fat should then be pulled toward the ridge in the apex of the orbit and fixed there with 4 catgut sutures so that the floor of the orbit becomes covered by thick pedunculated fat and connective tissue (Figs. 4 and 5). Figure 6 shows the result that is obtained following the second stage of the procedure.

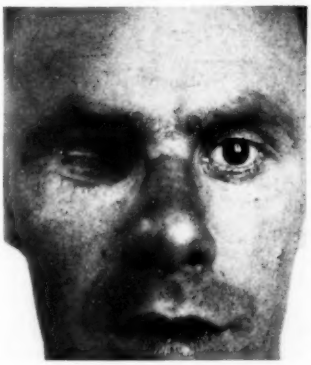

Fig. 1

Fig. 2

Fig. 3

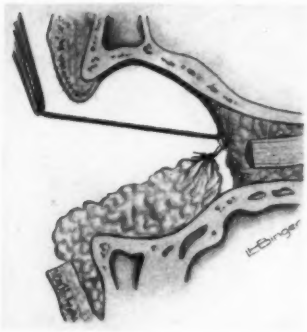

Fig. 4

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Fig. 6

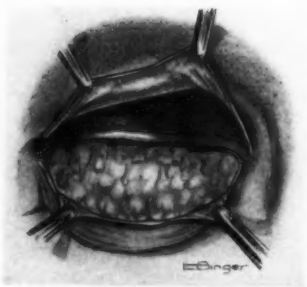


Fig. 7

Fig. 8

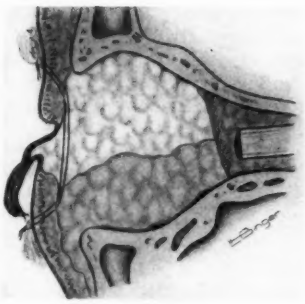


Fig. 9

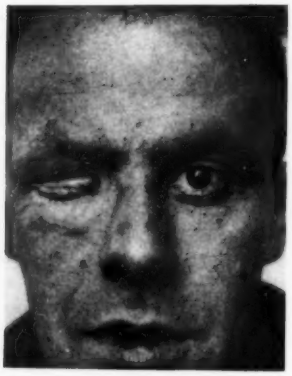


Fig. 10

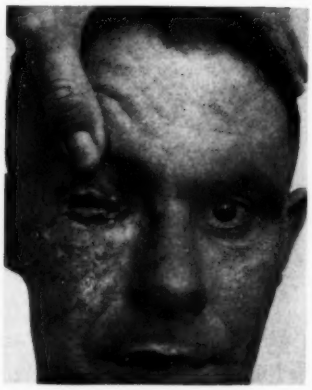


Fig. 11

Fig. 12

Figures 7 and 8 illustrate the first step in the third operation during which the skin is separated from the wall of the orbit. The floor of the orbit should be well covered by the pedunculated fat transplant introduced at the second operation and will serve as a bed for another free fat transplant from the lateral region of the opposite thigh. The nourishment of this latter transplant from the floor of the orbit is guaranteed by the preceding operation, but little blood supply can be expected from the bare bony roof. Therefore, eyebrow and cheek should be pulled together by strong sutures tied over strips of gauze to prevent their cutting through (Fig. 9). Thus a blood supply anteriorly will be acquired which cannot be furnished by the thin sheets of skin obtained from the floor and roof of the orbit. Figure 10 illustrates the appearance of the patient after this third operation. It will be seen that the amount of transplanted tissue is considerable. The eyebrow regains its normal contour after removal of the sutures. Figure 11 shows the cavity after the fourth operation in which a new opening in the tissue is made over a stent graft (Esser-Wheeler operation). It will be seen in Figure 12 that this cavity is large enough to hold an artificial eye. A minor cosmetic operation on the inferior eyelid and the external canthus, a well made artificial eye, and the patient's glasses aid materially in restoring a normal appearance.

INTRACRANIAL COLLECTIONS OF IODIZED OIL FOLLOWING LUMBAR MYELOGRAPHY

L. HENRY GARLAND, M.D., and EDMUND J. MORRISSEY, M.D., F.A.C.S.,
San Francisco, California

ONE of the most valuable applications of contrast media in the diagnosis and localization of certain lesions of the spinal cord is the use of iodized oil in the subarachnoid space. This space was first visualized pre-operatively with air by Dandy in 1919, but, following the introduction of lipiodol by Sicard and Forestier in 1922, air was soon replaced by the use of small amounts of opaque oil. Air is of such low contrast in comparison with lipiodol that one can understand Dandy's remark, "the poorest radiograph made with lipiodol is superior to the best one made with air." This was quite true, when one makes allowance for the contrast obtainable in roentgenograms at that time; however, with modern roentgenographic technique, Chamberlain and others have shown that air may be a very useful contrast medium, especially in thin subjects. On the whole, however, most physicians regard the use of opaque oil as superior to that of air and, of the opaque oils, lipiodol is perhaps the one most used at the present time.

It has been known for many years that the opaque oil remains indefinitely unless removed at operation, which is a very difficult and seldom accomplished feat, and that it may be scattered throughout the entire cerebrospinal fluid pathway. Most clinicians are of the impression that it is somewhat irritating, and that it is apt to become encapsulated in or about the lower portion of the spinal sac. Some time ago it was our privilege (E. J. M.) to see in consultation a patient who had rather bizarre cerebral symptoms. Roentgenographic examination of this patient's skull revealed large amounts of opaque oil in the ventricular and subarachnoid spaces (Fig. 1), residual from lumbar myelography performed 2 years previously, and the question arose as to whether or not the cerebral symptoms were due to the intracranial oil (Case 1). A survey of the literature revealed no specific information on clinical symptoms or pathological changes due to prolonged retention of lipiodol intracranially, although there was considerable material on late changes in and about the meninges of the cord. In order to study this problem under clinical conditions, it was decided to have return for examination a group of patients, who had had lipiodol injected into their spinal canals several years previously. The present paper is a résumé of the clinical and roentgenological findings in these patients, a report of the autopsy findings in one case, and a review of the literature.

From the Departments of Medicine (Radiology) and Surgery, Stanford University School of Medicine and the San Francisco Hospital, Department of Public Health.

CLINICAL AND PATHOLOGICAL REACTIONS REPORTED IN THE LITERATURE

There are numerous reports of local reactions both early and late, following the injection of opaque oil in the spinal subarachnoid system, but only scant literature dealing with reactions in and about the cerebrum. This is rather surprising, since even in their earliest publications, Sicard and Forestier reported the presence of the oil in the cranium following maintenance of the patient in Trendelenburg position for some minutes.

Intraspinal (subarachnoid) lipiodol. Sicard and Forestier both in their early publications in 1922 and later monograph in 1928 reported that immediately after the subarachnoid injection of lipiodol there was an increase in the white cell count of the spinal fluid lasting for about 4 days; that in patients whose spinal subarachnoid space was normal, there were sometimes symptoms such as mild headache and cramps in the lower limbs, and a rise in temperature of about 2 degrees Fahrenheit. This reaction lasted for 1 or 2 days, and usually subsided without leaving any residual symptoms. In patients whose meninges were inflamed or congested as a result of recent trauma, "contact of the oil with the diseased area sometimes caused a transient but quite endurable pain." In paraplegics there was sometimes an increase of spasticity and slight inhibition of the sphincters. In tabetics, there were short crises of shooting pains, tingling of the lower limbs, and occasionally transitory disturbances of the sphincters. Patients afflicted with general paresis did not show any reactions at all. In all of their cases reactions of this kind disappeared completely within 4 days. They believed that a simple lum-

bar puncture was capable of producing similar effects in certain cases. They did not observe any late reactions, although they reported that the lipiodol disappeared very slowly.

Ayer and Mixter in 1924 performed some experimental work on cats and found very high spinal fluid cell counts following cisternal injection of 40 per cent iodized sesame oil. However, in proportion to the dosage used in humans their animal dose was approximately 5 times as great. Maclaire in 1925 and Sharpe and Peterson in 1926 reported what they believed was a case of severe meningeal inflammation following the use of lipiodol. The patient had sustained a fractured fourth thoracic vertebra; a few years later signs of spinal cord compression and irritation developed. Subarachnoid lipiodol injection revealed a block at the level of the seventh thoracic vertebra. Laminectomy was performed at the level of the fourth thoracic vertebra; nothing abnormal was found; the incision was closed. The patient grew worse and 5 months later laminectomy was performed at the level of the tenth thoracic vertebra; the lipiodol was found encysted in adhesions and there was considerable local arachnoiditis. Maclaire and Sharpe believed that the lipiodol alone brought on the meningeal inflammation. Sicard, discussing this case, believed that the adhesions and arachnoiditis antedated the injection of the oil, but again emphasized the occasional disturbances produced by lipiodol in cases of old spinal traumatism. Ebaugh and Mella in 1926 reported a transient aseptic meningitis following intracisternal injection of iodized oil in 13 cases. Wolfsohn and Morrissey in 1927 reported inflammatory changes around tumors in 2 cases following lipiodol injection.

Globus and Strauss in 1929 reported the results of subarachnoid injection of lipiodol in 64 cases. They concluded that in only one out of this group was there any clinical evidence of meningeal irritation; in this patient there was transient vasomotor disturbance and pain in segments approximating the level of the oil and tumor. They noted that 25 patients who had had iodized oil in their spinal canals for more than 2 years were normal upon examination, both roentgenologically and neurologically. Although the oil showed little diminution in bulk "it remained freely movable within the subarachnoid space and showed no evidence of any adhesive process." In one instance a necropsy was performed 3½ months after injection; there was no evidence of any inflammatory process of the meninges at the site at which the iodized oil had been arrested. They believe that the iodized oil was absorbed extremely slowly but that it remained freely movable. Elsberg, in discussing this paper, stated, "I thoroughly believe that iodized oil is an irritant. I have seen in a number of instances fresh adhesions and marked congestion of the meninges, changes which are not ordinarily observed when the spinal cord is exposed during laminectomy; I have always explained this as the result of the irritative qualities of this foreign substance."

Davis, Haven and Stone in 1930 reported the results of intracisternal injection of lipiodol in 10 dogs. In 8 of them they found a severe leptomeningeal reaction and concluded that the injection of iodized oil into the subarachnoid space was a dangerous procedure. They did not report the findings in control dogs, all animals having had artificially produced subarachnoid blocks.

Lindblom performed a critical investigation in 1931 of the effects of various iodized oils on the meninges. He found that the degree of irritation caused by the oil varied with the amount of free fatty acid: sesame oil, acidity 0.6, produced no irritation; refined poppy seed oil, acidity 2.4, produced moderate irritation; while ordinary poppy seed oil, acidity 6.5, produced marked irritation. He found that the iodized product of the oil caused greater irritation than the oil itself, the free fatty acid being transformed into iodic fatty acid. He regarded lipiodol as an impure iodized oil but found that its impurities were absorbed comparatively easily, while the iodized oil itself was absorbed slowly. He noted in rabbits that after the injection of oils that were absorbed slowly, a sort of "pseudo-tumor" or fatty granuloma was sometimes found in the subarachnoid cavity. These did not always develop and when they did develop took at least 6 months. Two rabbits were given injections of 1 cubic centimeter each of lipiodol and were killed after 6 months. Before the brains were extracted the skulls were roentgenographed. In one the oil was found to have collected in large lakes, while in the other it was distributed in numerous small droplets. When the brain was removed from the former it was found to contain 2 large lakes of oil surrounded and infiltrated with new-grown connective tissue. At a third place there was a pachymeningitic reaction which on incision also showed droplets of oil. Histological examination showed that these formations consisted of fatty phagocytes of various sizes, surrounded or infiltrated with new-grown connective tissue (fatty granulomas). In the other specimen, in which the oil was separated into small droplets, there were no

granulomas; numerous small droplets were found in the arachnoid membrane itself but without reaction. Lindblom observed "the literature contains a few cases of dissection on humans after lipiodol injection; judging from the histologic descriptions it seems likely that fatty granulomata were present in some of them. These granulomata appear to develop when the oil gathers in large lakes. Further investigation is required to confirm this point and *also to determine whether or not these granulomata have any clinical significance.*"

Brustin and Propper reported the results of experimental myelo-encephalography in dogs in 1931. They injected iodipin subdurally and found no disturbances of sensation or motor function. Pathological examination after from 1 to 3 months revealed granulation tissue formations over the spinal cord; in some areas there was destruction of the gray substance of the cord itself; however, it should be noted that the oil was injected into the cord itself in 2 dogs. These authors believe that the iodine and oil split up, the former producing the reaction.

Fumarola and Enderle reported one alleged fatality in 1932 following the cisternal injection of lipiodol, but gave no histological details. Hampton and Robinson in 1936 reported the absence of any serious or permanent reaction following the use of 2 cubic centimeters of lipiodol in over 100 examinations, and 5 cubic centimeters in 75 examinations. They observed that the oil often produces a definite reaction, lasting for several days, characterized by elevation of the spinal fluid cell count, changes in the color and chemical composition of the fluid, headaches, increase in the pain of which the patient complained, and slight fever. They comment that those that use the oil most frequently find the fewest reactions. They state that the oil did not become encysted even after 2 years. However, they do not recommend the indiscriminate use of the oil "and examine the upper thoracic spine only when symptoms referable to that portion of the canal are present . . . . which may account for the infrequency of some of the untoward reactions which others attribute to the use of lipiodol."

Intracranial (ventricular and cisternal) lipiodol. Sicard and Forestier, in 1926, suggested the use of ordinary lipiodol[1] for outlining the cerebral ventricles and published illustrations of a few cases; however, 6 years later they advised against it, owing to early reactions in the form of severe headache and pyrexia. They observed no untoward late effects, however. Sicard and others reported the use of "ascending lipiodol" and of ascending lipiodol emulsified with spinal fluid in ventriculography. They found the latter mixture to be exceedingly irritating "because of the extremely small state of division of the oil droplets, which are more easily attacked by the white cells and minute quantities of iodine liberated." They found that in tuberculous meningitis the reaction was intense, being accompanied by nausea, vomiting, and even exitus, and advised against the use of either ordinary or light oil for such purposes.

Brandt, in 1933, reported the case of a patient with tuberculous spondylitis in whom 2 cubic centimeters of iodipin had been injected into the lumbar subarachnoid space 5½ months prior to autopsy. At autopsy numerous bright yellow nodules, varying from 1 to 4 millimeters in diameter and resembling grapes in shape, were seen about the base of the brain, being especially numerous in the region of the basal cisternæ. These appeared to lie between the pia mater and the brain. They were easily movable and burst on slight pressure. Chemical examination showed that these nodules contained iodine. Microscopic examination showed only a structureless membrane. No pathological changes attributable to the iodine could be found in the neighboring brain.

Ouchi, in 1935, discussed 25 cases in which he had used opaque oil for myelography. In several of these cases he reported mild early reactions such as nausea, irritability, pyrexia, and so forth, all of which disappeared within a week. In one instance he erroneously injected the oil in a case of tuberculous meningitis; shortly thereafter the patient died. Ouchi attributed the patient's death to the meningitis and not the lipiodol. However, he believed that it may well have aggravated the patient's disease. In 7 cases he believed the oil exercised a therapeutically beneficial influence. In no cases did he meet with late harmful effects and did not think the oil showed any tendency to become encapsulated or form granulomas "as described in the literature."

Schuller, in 1936, investigated patients with possible tumors at the base of the brain by suboccipital or intraspinal injection of 40 per cent iodipin. He recommended this contrast filling of the basal cisternæ because (1) the material was stable and there were no immediate or late unfavorable reactions, (2) the material was easily visible under the fluoroscopic screen, and (3) following investigation of the basal cisternæ the opaque oil could be displaced into the spinal subarachnoid space and thereby retained for further,

[1] By ordinary lipiodol we mean iodized poppy seed oil, 54 per cent. "Ascending lipiodol" is a special light oil and contains only 11 per cent iodine.

later investigations of the cisternæ. His article contains 9 illustrations showing oil in the skull, mostly in the form of lakes.

Carillo, in 1936, discussed the use of lipiodol for examination of the ventricular cavities. Details as to its complications are lacking.

Lysholm, in 1938, discussed his experience with ventriculography, using both air and opaque oils, based on a total material of 3,408 cases during 10 years. Of these cases, 123 were lipiodol examinations, concerning which he comments that undesirable reactions sometimes occurred and that air is preferable and much less harmful.

SUMMARY OF REACTIONS REPORTED IN THE LITERATURE

Reactions to the subarachnoid injection of iodized oil[1] may be summarized as follows:

Spinal canal. A. Immediate reactions: Pathologically there is elevation of the spinal fluid cell count and slight hyperemia about the site of injection. Clinically there may be slight headache, increase in the pain of which the patient is complaining, slight fever, and sometimes pain about the sacrum and coccyx. These pathological and clinical changes last about 2 to 5 days and then subside.

B. Late reactions: In patients without infectious or traumatic lesions involving the spinal cord or meninges there are usually no late clinical reactions. Coccygeal pain, if present, usually subsides within 3 months. The oil may lie in small droplets and lakes scattered up and down the spinal canal, sometimes extending out along the nerve sheaths. Many of the smaller droplets may be movable. Occasionally the oil becomes encapsulated in the cul-de-sac at the base of the spinal canal. For as long as 3 years following injection the larger collections may show considerable motion, and may even be used for refilling various portions of the spinal canal for investigation. After about 3 years they tend to become encapsulated in various areas. Fibroblastic proliferation and pseudogranulomas may develop about the oil.

Cranial cavity. There have been only a few references to immediate or late reactions in the cranial cavity. Those authors who deliberately used the oil to explore the basal cisternæ reported minimal reactions of a transitory nature, while those who used it to explore the ventricles reported more unpleasant reactions, leading as a rule to the discarding of the method. Many authors have referred to possible late clinical reactions from the presence of lipiodol or other opaque oil in the cranial cavity, but none have reported specific examples. It is to clear up any doubts on the latter that this paper is being presented.

In concluding our remarks on the literature dealing with reactions to the subarachnoid injection of lipiodol, it is to be remembered that mild reactions also follow the injection of air. Of course, no granulomas have been found following simple spinal puncture or air injection, but most of the clinical reactions above noted have been reported following the injection of air. As Lindblom observes, "further investigation should be made to determine whether or not the lipiodol granulomata have any clinical significance."

Most neurosurgeons and clinicians, discussing the use of subarchnoid lipiodol in the diagnosis of spinal cord lesions, emphasize that the oil should be aspirated at the time of laminectomy. Indeed, most surgeons routinely report that "oil was removed at operation." Roentgenological investigation has convinced us that it is rare that more than one third of the oil has been removed. Lucherini, in 1936, described a method of removing the oil by making a burr opening in the sacral crest at the level of the second sacral body, puncturing the dura and arachnoid, and aspirating the oil. Nosik and Mortensen in an effort to obviate the "unpleasant symptoms of root irritation produced by lipiodol" recently used thorotrast in experimental animals. Following its use they lavaged the cerebrospinal system in order to remove it. This appears to us to be an unnecessarily complicated procedure. Mettier and Leake stress the importance of removing all traces of oil at operation, without apparently realizing how difficult a task this is. Indeed, we suspect that undue efforts at removal would be more harmful than leaving the oil *in situ*.

REPORTS OF CASES RETAINING OIL INTRACRANIALLY

Having had our attention drawn to the presence of lipiodol in the cranial cavity by the case mentioned in the opening paragraph of this paper, we reviewed with the invaluable assistance of Dr. Earl Miller those cases in our files in which we could get patients to return for examination, excluding the spinal cord tumor cases, which are being reported separately. All the patients recalled had received subarachnoid lipiodol injections from 1 to 13 years previously, 3 to 5 cubic centimeters of oil having been used in most instances. In 9 of these patients no lipiodol was found in the skull at the time of roentgenographic examination. In

[1]We are assuming that the oil used is a non-irritating, purified vegetable oil of low acidity, and containing from 30 to 60 per cent iodine or similar halogen, that it is in absolutely fresh condition, and is used in amounts of not over 5 cubic centimeters.

Fig. 1a

Fig. 1b

Fig. 1c

Fig. 1 a. Case 1. Intracranial iodized oil for 2 years. This patient had 4 cubic centimeters of lipiodol injected into the lumbar subarachnoid space in January, 1937. At the present time large globules of lipiodol are scattered throughout the subarachnoid spaces over the right parietal region; some in the base of the anterior, middle and posterior fossæ, and some in the third and lateral ventricles. These globules show negligible change in position with changes in posture and are apparently fixed, or encysted on various portions of the pia and arachnoid. No clinical symptoms attributable to the oil. b, Lateral projection. c, Occipital projection. See Figure 1 a.

16 patients oil was found, large amounts in 7 and small amounts in the 9 remaining. In order to confirm other observers' reports on the lack of immediate symptoms following introduction of lipiodol into the cranial cavity, we examined 2 patients immediately and also 1 week after lumbar subarachnoid injection of lipiodol, placing them in extreme Trendelenburg position, and filling their intracranial subarachnoid spaces. In neither of these patients were any symptoms noted which could be attributed to the lipiodol in and about the brain.

Of the 16 patients who had lipiodol in and about the brain for from 1 to 13 years, several had vague neurological complaints. Careful review of all of these patients' histories revealed that identical complaints existed before the date of first lumbar puncture and injection of lipiodol. In no case was there any new symptom which could be attributed to the presence of the oil in the brain or meninges.

In order to emphasize this point we are recording the neurological symptoms and findings before the injection of lipiodol, and those noted after x-ray examination revealed the opaque oil in and about the brain in the 9 most instructive cases. The other cases have been summarized. We are also reproducing the roentgenograms of several of these cases, and the histological appearances

of the cerebral meninges in one case in which we secured an autopsy.

CASE 1. J. V. C., 53 year old engineer, complained of severe pain in the lumbar region occasionally radiating down the posterior surface of the left thigh and leg. No evidence of subarachnoid block was noted following lipiodol injection. Lumbosacral fusion was performed. Five months later he developed cerebral symptoms. Roentgenograms of the skull showed lipiodol scattered throughout the subarachnoid space and ventricles (Fig. 1).

The patient was first seen on December 8, 1936, being referred by Dr. J. M. Meherin. The family and past history was essentially negative except that he was kicked over the left frontal region by a cow at the age of 11. The patient was not unconscious and has had no cerebral symptoms attributable to the injury. The patient denied any previous back injuries. On July 14, 1936, as he was walking backward, pulling a car load of cord wood down a ramp, his foot slipped, and he slid off into a pit. He immediately noted pain in the lower back which radiated down the back of his left thigh and leg to his toes. He climbed out of the pit and lay down for about 15 minutes, following which he went home. Next morning he was unable to get out of bed because of the severe lower back pain. On July 29, 1936, he had severe spasms of pain in the left thigh and leg and was taken to the hospital by ambulance. The spasm lasted for about 1 week and was somewhat improved by hot compresses. About 1 week after the accident he first noticed numbness along the lateral side of the left thigh and leg, and the foot felt colder than the other. He was discharged from the hospital after 6 weeks, remained in bed at home for 1 week, and was then allowed up and about. His condition did not improve.

Examination on December 1, 1936, showed the patient to be well developed and nourished. Temperature, pulse, and respiration were normal; blood pressure 108/70. The general physical examination was essentially negative except for spasticity of the lumbar muscles on both sides, flattening of the lumbar curve, tenderness to pressure over the third, fourth, and fifth spinous processes, especially the latter, and pain referred to the lumbosacral region on any movement involving the lumbar spine. Neurological examination: Head: Size and shape were normal. There was a healed, horse-shoe shaped laceration over the left frontal region. There were no areas of depression, no tenderness, and no changes on percussion. Cranial nerves: Sense of smell was normal. Visualacuity was fair; perimetric fields were normal. Ophthalmoscopic examination showed the discs to be of normal color, cupping present, margins fairly well defined, veins rather full and slightly engorged, arteries normal, and no hemorrhages or exudate. The pupils were round, equal, and reacted to light and accommodation. All external ocular muscle movements were normal. There were no sensory changes over face; muscles of mastication were normal; no facial weakness or asymmetry were present. Hearing was good in both ears. No nystagmus, past pointing, or ataxia were present. Gag and palate reflexes were normal. There was no weakness of the trapezius or sternocleidomastoid muscles; the tongue protruded in the midline with no atrophy. Lobes of brain: Patient was oriented as to time, place, and person. There was no aphasia, no definite muscle weakness, no sensory changes, no involvement of the perimetric fields, and no stereognostic disturbances. There was no past pointing, nystagmus, nor ataxia, and the Romberg was negative. Reflexes: Upper reflexes were present and equal; abdominal reflexes were present, equal, and slightly hyperactive; patellar and Achilles, present and equal. There were no pathological reflexes or clonus. Sensory: There was possibly some hypesthesia to touch and pain over the lateral surface of the left thigh but no definite area could be outlined. Roentgenograms of the lumbar spine showed a marked narrowing of the lumbosacral joint and moderate narrowing of the fourth disc. The sacral articular processes impinged on the pedicles of the fifth lumbar vertebra. There was considerable sclerosis of the lumbosacral facets. A spinal puncture was done and the fluid found to be clear, colorless, pressure not increased; Queckenstedt negative; no increase in cell count or total protein, and Wassermann reaction negative.

Because of the root pain brought on by coughing, straining, etc., and the slight weakness over the lateral surface of the left thigh and leg, lipiodol injection was done, but no block was noted. On January 26, 1937, a lumbosacral fusion was performed. The postoperative course was uneventful and he returned to light work in October, 1937. The patient was referred to us again (E. J. M.) in April, 1938, and at that time he stated that for the past year, beginning while he was still wearing a body cast, he had had attacks during which he would become dazed and fall to the floor. He would get up immediately and feel normal. He did not bite his tongue, froth at the mouth, or have convulsive movements and there was no disturbance of sphincters. In September these attacks occurred as frequently as 5 or 6 times a day. In October, 1937, while driving a car he became unconscious, recovering later, at which time he was lying down on the front seat with the switch turned on and the car in the middle of a field. When he got out he was confused and had to walk along the road for some distance until he met a friend who directed him to his home. On another occasion he went under a building to clean out some steam traps and then remembers nothing until 6 hours later when he was found by searchers. He is still complaining of pain over the lumbosacral region brought on by lifting or working in a stooped position. The pain no longer radiates down either leg and is not associated with muscle weakness or numbness. It is rather significant that the patient did not report any of these fainting attacks on his visits to the surgeon who performed the fusion. Examination in April, 1938, showed the patient to be well nourished and developed. Pulse, respiration, and blood pressure normal. The general physical examination was essentially negative, the operative incision in the lumbar region being well healed and not tender to pressure. There was some slight limitation of flexion, otherwise the spinal movements were normal.

Neurological examination in April, 1938: Head negative. Cranial nerves: negative. Reflexes: present and equal. No pathological reflexes or clonus. Sensory: No sensory changes to touch and pain. Motor: No muscle weakness or paralysis.

Roentgen examination of the skull in April, 1938, revealed no injury to the calvarium. There was some calcification of the dura behind the dorsum sellæ. There were numerous globules of lipiodol scattered throughout the subarachnoid spaces over the right cerebral hemisphere, some over the cerebellar hemispheres, some around the anterior and middle fossæ and, apparently, in the third and lateral ventricles. These globules appear to be fixed. There are a few globules scattered throughout the cervical portion of the spinal canal.

Although the neurological examination is negative for any positive neurological findings or evidence of increased intracranial pressure, the cerebral symptoms are somewhat suggestive of epileptic seizures and, therefore, one must consider several possibilities such as tumor, abscess,

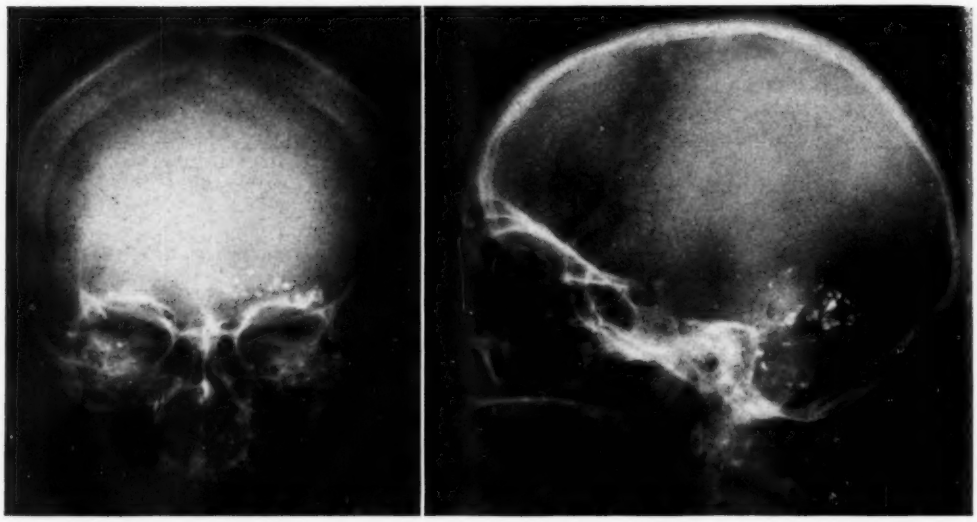


Fig. 2 a, left. Case 2. Intracranial iodized oil for 4 years. This patient had 3 cubic centimeters of lipiodol injected into the lumbar subarachnoid space in November, 1934; no organic intraspinal lesion found. At the present time there are numerous globules of lipiodol scattered throughout the third and fourth ventricles, basal cisternæ, and just below the base of the cerebellum. Globules apparently fixed. No cerebral symptoms. b, Lateral projection.

vascular disturbances, changes resulting from the lipiodol, etc. However, after going carefully into the history of the attacks, it was my opinion (E. J. M.) that there was a very large functional element present. It seemed very unusual that a patient, having the number of attacks which he claims and which were associated with loss of consciousness, did not report them to his physicians or to the insurance company; further, at no time did he receive any injury in the various falls.

Dr. Walter Schaller also examined this patient and found the neurological examination to be entirely negative. He stated that the attacks which the patient described, which were somewhat suggestive of epileptic seizures, were not due to any organic lesion and could not be the result of the intracranial lipiodol. He uncovered the fact, which the patient previously denied, that he had sustained a former lumbar injury, for which he had been and still was receiving Veterans' compensation. Proof that the cerebral symptoms were not the result of any organic cerebral lesion was the history given in March, 1939, that the dizziness and mental symptoms had disappeared following a second lumbosacral fusion.

CASE 2. S. L., a 44 year old female WPA[1] worker, showed intracranial iodized oil 4 years after lumbar subarachnoid injection of 3 cubic centimeters.

[1]Works Progress Administration.

This patient entered the San Francisco Hospital in October, 1934, complaining of pain in the left upper abdominal region for 3 weeks. She was a 40 year old white, American housewife, who stated that in addition to the recently developed abdominal pains she had constant aching between the shoulders for 4 years, and numbness and tingling of the legs for 2 years. On further questioning she stated that she had had severe menstrual headaches for 25 years, dysuria for 8 years and, indeed, "most of the symptoms suggested to her, such as palpitation, etc." Pelvic examination was negative. Roentgenographic examination of the spine was negative. Clinical diagnosis: Psychoneurosis, possible spinal cord lesion. On November 19, 1934, 3 cubic centimeters of lipiodol was injected by lumbar puncture. No abnormal findings were noted. One week following subarachnoid injection of the oil, the patient stated that she felt better, since "the medicine in the spine must be working." She was discharged 1 month later, moderately improved.

Roentgenographic examination in June, 1938, revealed large collections of lipiodol in the cerebral ventricles and about the basal cisternæ and subarachnoid spaces (Fig. 2).

Neurological examination in June, 1938, revealed that the cranial nerves appeared normal. Gait and speech were normal. There was no weakness of the muscles of the neck, shoulder girdle, arms, thighs, legs, or trunk. No atrophy was evident. The reflexes appeared normal. Except for a small area on the back, just below the right scapula and corresponding to the fifth and sixth intercostal spaces, where there was slight hyperesthesia, there was no impairment of pain, light touch, position, or vibration. Clinically, the patient had no new symptoms since myelography.

This patient had large amounts of lipiodol both intracranially and intraspinally for 4 years. She

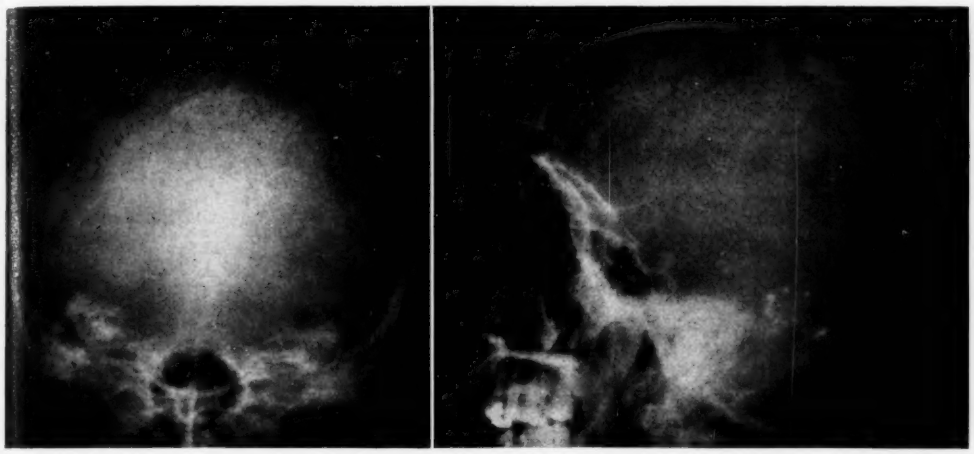


Fig. 3 a, left. Case 3. Intracranial iodized oil for 4 years. This patient had 4.5 cubic centimeters of lipiodol injected into the lumbar subarachnoid space in January, 1935. At operation (lumbar laminectomy) "all of the lipiodol was washed from the spinal canal and the wound closed." At the present time there are numerous globules between the cerebral lobes, postero-inferiorly, and one in the cisterna pontis. Oil apparently fixed. No symptoms or neurological findings attributable to iodized oil. b, Lateral projection.

had no symptoms or neurological findings which could be attributed to the presence of the oil. All of her multifarious subjective symptoms were present and noted in her history before the injection of the oil in October, 1934.

CASE 3. A. J., a 40 year old longshoreman, showed intracranial iodized oil 4 years after lumbar subarachnoid injection of 4.5 cubic centimeters.

In December, 1934, this patient slipped and fell while at work. He was admitted to the hospital complaining of severe pain in the lower back, extending down the posterior surface of the right leg. There was slight atrophy of the muscles of the right leg. The patient stated that this had been present since an operation just above the right knee at the age of 9. Neurological examination: The cranial nerves appeared normal. There was slight atrophy of the right side; no sensory disturbances could be detected. The right knee jerk was more active than the left; the right ankle jerk was weak. The remaining reflexes were normal. On January 15, 1935, 4.5 cubic centimeters of lipiodol was injected by lumbar puncture and a filling defect was noted on the left side of the fourth lumbar disc. At operation in February, 1935, thickening of the arachnoid was noted on the left side of this disc, but there was no evidence of tumor or retropulsion. "All of the lipiodol was washed from the spinal canal and the wound closed."[1] Microscopic examination of the tissue removed was reported as chronic arachnoiditis. No definite cause for the sciatica was found. The patient improved for a while, but after some months the symptoms recurred and, when admitted to the San Francisco Hospital, he was again complaining of pain in the back and down the right leg.

Roentgen examination of the skull in 1938 revealed numerous globules of oil lying between the cerebral lobes, postero-inferiorly, and one in the cisterna pontis. The oil appeared fixed.

Neurological examination in 1938 revealed that the cranial nerves appeared normal. There was slight atrophy of the right thigh and calf. The right knee jerk was more active than the left; the right ankle jerk could not be elicited. The other reflexes were normal. No defect of any sensory field was detectable. The Romberg was negative. There was tenderness over the course of the sciatic nerve on the right side in the mid-thigh level. Clinically the patient had no new symptoms of intracranial origin.

This patient had large amounts of iodized oil scattered throughout the cranium 4 years following lumbar myelography. No symptoms or neurological findings attributable to the iodized oil were detectable. It is of interest to note that the surgeon in this case, as in so many others in our experience, believed that he washed all of the opaque oil from the spinal canal at the time of operation, while subsequent examination showed that perhaps not more than one-third was actually removed.

CASE 4. H. J., a 25 year old clerk, showed intracranial iodized oil 4 years after lumbar subarachnoid injection of 3 cubic centimeters.

This patient entered the San Francisco Hospital in August, 1934, complaining of pain down the backs of both legs, for about 4 years. This developed gradually while he was working in a warehouse lifting heavy objects, and the pain was worse on the right side. Neurological examination disclosed no evidence of cranial nerve disturbance. The patient stated that he had had a few dizzy spells in the past but not in recent years. There was pain in the right sacro-iliac region on flexion and extension of the trunk,

[1] Note by Dr. H. Fleming, through whose courtesy this portion of the history was reviewed.

Fig. 4. Case 6. Photograph and roentgenogram of the lower portion of the spinal cord of patient who had 3 cubic centimeters of lipiodol injected one year previously. Light spots (lipiodol) are present on and lightly adherent to the arachnoid over the lower 5 centimeters of the cord and the cauda equina. Microscopically, these are composed of fibroblastic proliferation about small vacuoles, without any inflammatory type of reaction. Roentgenologically they show as punctate opacities. Similar globules of lipiodol with associated cellular reaction ("pseudogranulomas") are present in the meninges over the base of the brain.

with local tenderness on pressure over the sacro-iliac joints. The reflexes and sensation were normal. Roentgenographic examination revealed no abnormal findings in the spine. The tentative clinical diagnosis was possible spinal cord lesion in the lumbar region. Lumbar myelography was performed in April, 1935, 3 cubic centimeters of lipiodol being injected. This disclosed nothing definitely abnormal. Following this a lumbosacral fusion was performed and the patient was discharged.

Roentgen examination of the skull in 1938 revealed the presence of one small droplet of oil in the cisterna chiasmatis, apparently fixed.

Neurological examination revealed no evidence of cranial nerve disturbance. The strength of the neck, shoulder girdle, trunk, and upper extremities was good and equal on both sides. Examination of the lower extremities was somewhat difficult because of pain associated with the carrying out of the tests, but there was no definite evidence of motor impairment. No significant atrophy was present. The left knee and ankle jerks were slightly more active than the right, similar findings having been noted in 1934. No pathological reflexes were elicited. On questioning, the patient stated that since operation the pain had disappeared from the thigh but had persisted in the back; he thought he had one new symptom, namely, that the leg had a tendency to kick out convulsively 3 or 4 times a day when sitting or lying in bed. He had no new symptoms of intracranial origin.

This patient had collections of iodized oil in his cerebrospinal system, some of it in his cranium, for over 4 years. No clinical symptoms and no neurological findings attributable to the presence of this oil could be detected at the end of that time. There was only a little oil in the cranium at the time of examination in 1938, and it was apparently fixed.

CASE 5. I. B., 31 year old housewife, showed intracranial iodized oil 2 years after lumbar subarachnoid injection of 3 cubic centimeters.

This patient entered the San Francisco Hospital in August, 1936, complaining of a feeling of numbness and coldness over both hips for 2 months, of awkwardness and tendency to stumble, and of cramps in the right calf. She was pregnant at the time and, following delivery 1 month later, was discharged with her symptoms improved but not entirely relieved. Re-examination next month following "seizure with cramps in both legs" revealed no evidence of pathological reflexes, although they were a little hyperactive on the right side. Under a tentative clinical diagnosis of space-occupying spinal cord lesion, lumbar myelography was done in October, 1936, 3 cubic centimeters of iodized oil being introduced by the lumbar subarachnoid route. The findings were negative. No operation was performed and the patient was discharged from the hospital slightly improved.

Roentgen examination of the skull in 1938 revealed a small globule of oil in the region of the cisterna pontis, apparently fixed.

Neurological examination in 1938 revealed no evidence of disturbance involving the cranial nerves. The reflexes appeared normal. About the region of the right buttock and upper half of the right thigh, roughly corresponding to the distribution of the lateral femoral cutaneous nerve, there was slight hypalgesia and hypesthesia. Otherwise sensation appeared normal. Symptomatically, the patient felt that she was improved, dating her improvement to a hysterectomy. She had no symptoms referable to her cranium.

This patient had a small amount of intracranial iodized oil for approximately 3 years. Clinically, this was productive of no symptoms and no disturbances of neurological origin.

CASE 6. S. G., a Hindu laborer, had 3 cubic centimeters of lipiodol injected into his lumbar subarachnoid space approximately one year previously. The patient died of independent causes almost one year following myelography and at necropsy lipiodol was found intracranially and intraspinally.

This patient entered the San Francisco Hospital in January, 1936, complaining of pain in the right leg and kidney trouble. He understood and spoke only a little

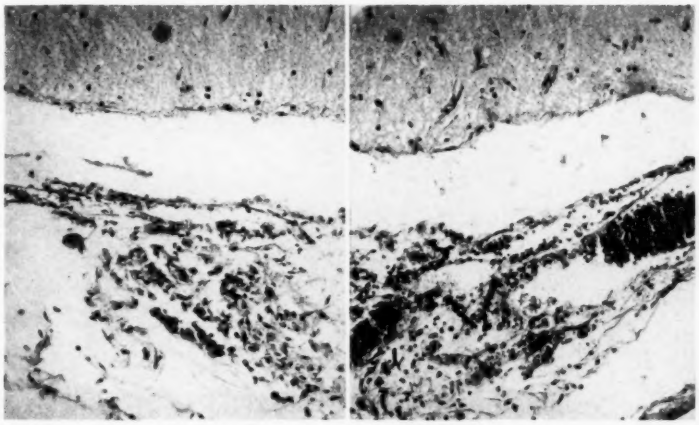


Fig. 5 a and b. Case 6. Sections from the arachnoid over the cerebellar hemispheres show fibrous proliferation, round cell infiltration, and a few foreign body giant cells containing minute fat droplets. There is no infiltration in the cerebellar cortex. Examination of similar areas over the cerebrum and cord also showed no microscopic evidence of infiltration (Dr. Dock).

English. He dated his troubles back to 1931, when he apparently had generalized edema following some kind of acute renal illness. Since that time he had had intermittent inability to urinate. In September, 1935, he noticed poor vision in the left eye; examination revealed haziness of the disc margin and exudate. By December, 1935, he was practically blind in both eyes. Roentgenographic examination of the skull revealed a little calcification about the anterior horns of the lateral ventricles, thought to be due to calcifying ependymitis, and of the meninges over the tips of the frontal lobes. Encephalograms revealed no evidence of tumor. Following removal of 5 abscessed teeth he thought his vision improved.

Neurological examination in 1936 revealed diminished sensory responses to touch and prick below the level of the seventh thoracic segment, and just above that level a band of hyperesthesia. There was some lack of vibratory sense in the legs and diminished reflexes in the right leg. The following clinical diagnoses were made: Encephalomyelitis of unknown origin; chronic glomerulonephritis; possible spinal cord lesion at the level of the seventh thoracic segment. In February, 1936, 3 cubic centimeters of lipiodol was injected into the lumbar subarachnoid space; no abnormal findings were noted. The patient's vision grew worse again, and neurological examination in March tended to confirm the previous clinical diagnosis of encephalomyelitis, and did not disclose any direct evidence of brain or spinal cord tumor. In May, 1936, the patient was discharged as improved; he could walk with crutches; his chronic glomerulonephritis and encephalomyelitis were somewhat improved; his optic neuritis was not improved. In November, 1936, he was readmitted to the Hospital in a sleepy condition, gradually became stuporous, and died on December 16. No roentgenograms of the skull were made subsequent to the time of lipiodol injection.

Autopsy was performed and the general anatomical diagnoses were: chronic cystitis, pyelonephritis, multiple renal abscesses, bronchopneumonia, fibrinous pleuritis, and acute tracheobronchitis. The findings in the central nervous system were bizarre and are reported in detail.

The cerebral convolutions appeared normal. In the meninges along both sides of the pons there were numerous tiny yellow "crumbs," non-adherent and lying on and under the arachnoid; these "crumbs" were made up of yellow spots and granulations. Similar yellow spots were seen on the arachnoid over the chiasm, the cisterna cerebellomedullaris, and the inferior portions of the cerebellar lobes. These varied from 1 to 2 millimeters in thickness, were lightly adherent and easily moved with a probe. There were yellow spots under the spinal dura and lightly adherent to the arachnoid of the lower 5 centimeters of the cord, being especially abundant on the conus and among the filaments of the cauda equina (Fig. 4). Smears of this yellow material and its adjoining granulations stained with sudan or nile blue and hematoxylin showed many fatty globules and fat-staining crystalline burrs, with many round cells in clumps and sheets. On cutting the brain, the lateral ventricles appeared normal in shape and volume, but their lining was coarsely granular. The granules were white and glistening; in one area in the left anterior horn there was a pale yellow tinge to the granules. The choroid was not remarkable. In the white substance of the left frontal lobe, near the vertex, was a slightly raised brownish lesion, measuring approximately 2.8 by 1.8 by 1.8 centimeters. Sections showed this to be composed of glial tissue with some edema; the oligodendrocytes and vascular walls appeared normal; a few unaltered astrocytes were present in its center, and there was some extracellular lipoid material. It was finally decided by Drs. Dock, Wood, and Usami that this lesion was an area of sclerosis of the brain of unknown origin; they did not think it was an infarct or xanthomatous plaque.

Sections of the brain stem, basal nuclei, cerebellum, and cervical spinal cord showed no noteworthy changes in the nervous elements. Sections of the lumbar cord showed some demyelinized fibers in both pyramidal tracts and in the anterolateral columns on the left side. There were small areas in the pia of the cauda equina in which signet cells, giant cells, and fibroblastic proliferation about small vacuoles indicated the site of the yellow granules seen

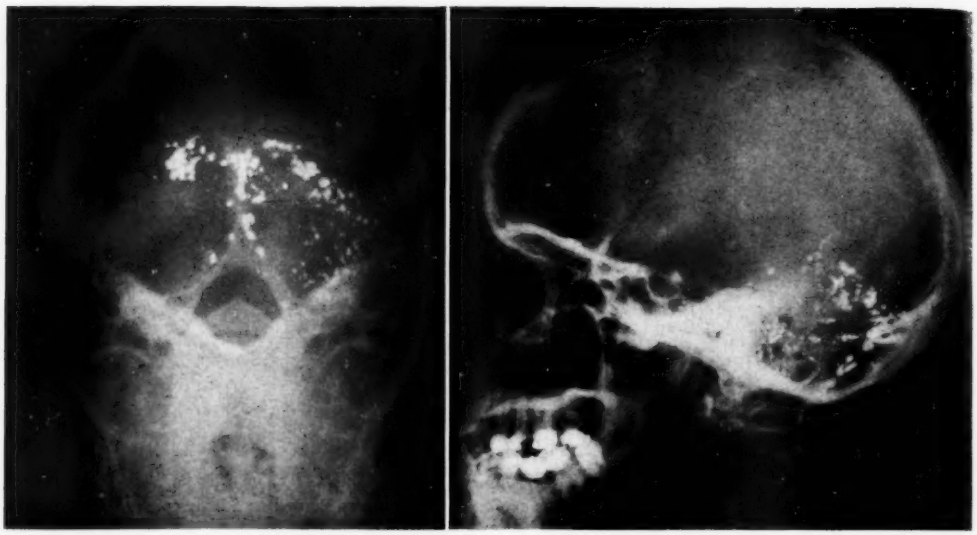


Fig. 6. Case 7. a, left, Intracranial iodized oil for 9 months. This patient had 3 cubic centimeters of lipiodol injected into the lumbar subarachnoid space in January, 1938. At the present time there are numerous globules and droplets of oil in the posterior fossæ, chiefly on the left side, and some in the left portion of the cisterna pontis. All of these globules are fixed. No clinical symptoms attributable to the intracranial lipiodol. Note: In this patient, as in all of the cases illustrated, there were small amounts of opaque oil present in the lumbar and sometimes in other sections of the spinal canal. Most of these collections were fixed but some of the larger spinal collections or lakes could be moved. Patient had no symptoms referable to her cranial cavity. b, Lateral projection.

grossly. There was scarcely any reaction of an inflammatory type. Similar reaction was seen in places in the meninges at the cerebellopontine angle close to the fourth ventricle. The thickened meninges of the region of the optic chiasm were spread out and stained with fat. Masses up to 5 millimeters thick were seen, as well as many finer droplets, down to 8 microns. The meninges were very cellular, but these were nearly all young fibroblasts. No giant cells or round cells were seen (Fig. 5).

The final diagnosis was: Sclerosis brain, left frontal lobe, localized, leptomeningitis, chronic, localized, with small collections of lipiodol in the meninges at the base of the brain and along the spinal cord; ependymitis granulosa, with calcification, in the anterior horn of the left lateral ventricle (Dr. W. Dock).

This patient had 3 cubic centimeters of lipiodol injected into his lumbar subarachnoid space 10 months before death. Following that injection no symptoms or neurological findings attributable to the presence of the oil could be detected. At the autopsy it was suggested that some of the peculiar cerebral symptoms might be secondary to the lipiodol found scattered throughout the subarachnoid space, but detailed histological study of the brain and spinal cord revealed no lesions in the neural tissues proper which could be attributed to the lipiodol; the only changes of the latter type were confined to the meninges and perhaps to the lining of the ventricles. The final histological diagnosis was multiple sclerosis and simple adhesive leptomeningitis.

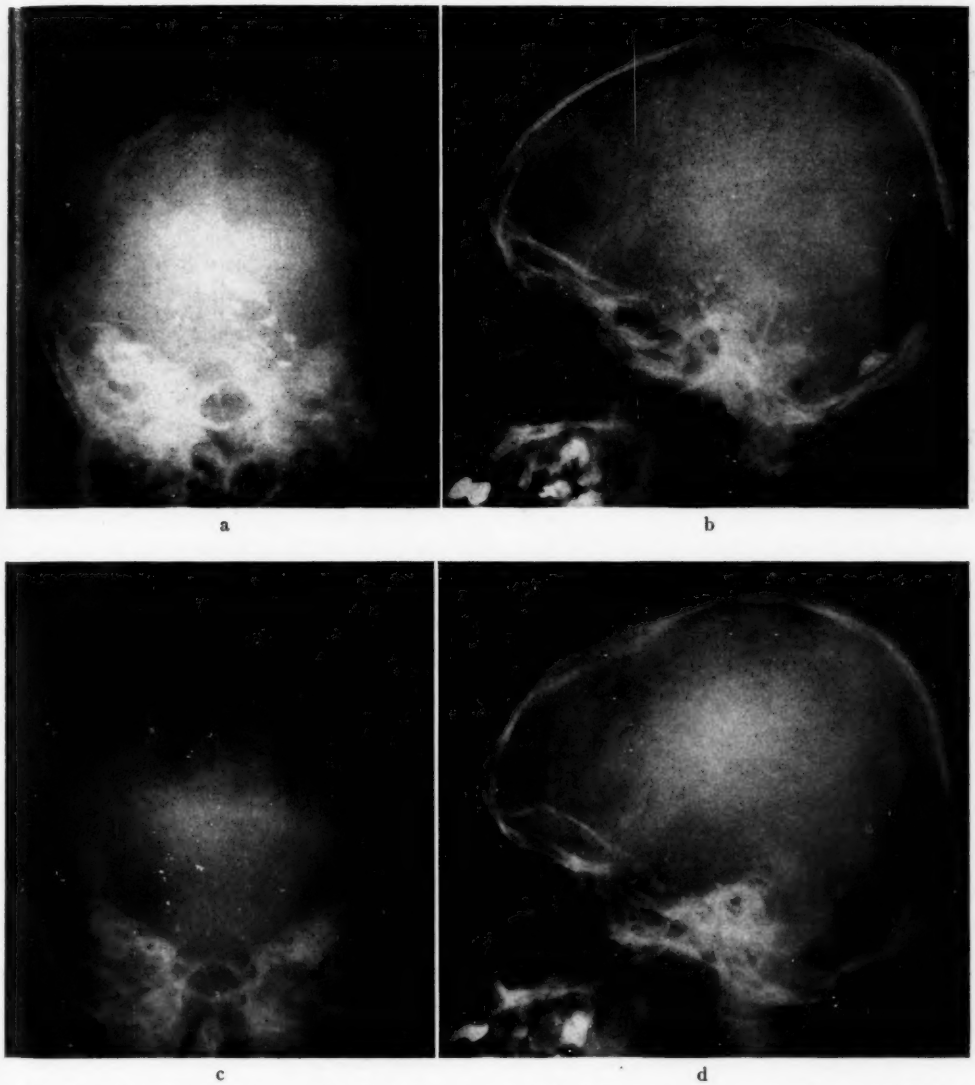
Case 7. H. W., a 30 year old housewife, showed intracranial iodized oil approximately one year after lumbar subarachnoid injection of 3 cubic centimeters.

This patient had severe backache and pain radiating down the right leg for over 1 year. There was no definite history of trauma. Following neurological examination it was deemed advisable to perform lumbar myelography. This was done in January, 1938, 3 cubic centimeters of lipiodol being used. A posterior displacement of a portion of the fourth lumbar disc was diagnosed. This was resected and the patient improved.

Roentgen examination in 1938 revealed the presence of numerous globules of oil in the posterior fossæ and some in the cisterna pontis. There were also small lakes of opaque oil in the lumbar portion of the spinal canal and a few droplets elsewhere in the spinal canal. The droplets were fixed, but some of the larger collections in the lumbar region were movable (Fig. 6).

Neurological examination in 1938 revealed no findings attributable to the oil. The patient had no symptoms referable to her cranial cavity.

This patient had fairly large amounts of intracranial iodized oil for a period of over 9 months. No symptoms or signs attributable to this oil could be detected.



a b c d

Fig. 7—a and b. Case 9. Intracranial iodized oil for 2 hours and 1 week. (See also next illustrations). This patient had 3 cubic centimeters of lipiodol injected into the lumbar subarachnoid space to determine the presence or absence of a spinal cord lesion. These films were made 2 hours later, following maintenance of the patient in Trendelenburg position for a few minutes. Numerous droplets of oil are seen scattered through the posterior fossa and about the basal cisternæ, without producing any symptoms. The lipiodol moved freely. c and d, Same case. Intracranial iodized oil for 1 week. Residual droplets of opaque oil noted in and about the basal cisternæ, 1 week following myelography. Most of these droplets were apparently fixed. No cerebral symptoms.

CASE 8. E. Z., a 37 year old Swiss salesman, showed intracranial iodized oil approximately one year after lumbar subarachnoid injection of 3 cubic centimeters.

This patient had severe pain low in his back radiating down the back of the right thigh and calf for a period of 5 months prior to admission to the San Francisco Hospital

TABLE I.—CASES SHOWING AMOUNT OF INTRACRANIAL OPAQUE OIL DISCOVERED BY ROENTGENOGRAPHIC EXAMINATION

Name	Age	Amount of iodized oil in cranium[1]	Interval between injection and examination of skull (years)
Cases showing oil within the cranium			
N. S.	71	†††	13
J. D.	50	†††	5
A. C.	30	††	5
S. L.	44	†††	4
A. J.	40	†††	4
H. J.	25	†	4
J. V. C.	55	††††	2
M. P.	50	††	2
M. W.	50	†	2
I. B.	31	†	2
L. L.	46	††	1½
S. G.	38	†	1
H. W.	30	†††	1
E. Z.	37	†††	1
W. H.	41	†	1 wk.
R. K.	33	†	1 day
Cases showing spinal oil but none within the cranium			
N. B.	61	o	7
M. L.	38	o	5
W. M.	56	o	3
C. T.	25	o	2
G. B.	32	o	1
P. E.	55	o	1
I. P.	43	o	1
P. P.	46	o	3
K. McC.	33	o	½

[1]Amounts of iodized oil in cranium are indicated as follows: † =small amount; †† =moderate amount; ††† =fairly large amount; †††† =large amount. See illustrations.

in October, 1937. The pain followed a fall from a 25 foot wall. Roentgenographic examination revealed no abnormal findings. Clinically a tentative diagnosis of retropulsion of the fifth lumbar disc was made. Lumbar myelography in October, 1937, with 3 cubic centimeters of oil, disclosed a retropulsion of the fifth lumbar disc. At operation in October, 1937, this retropulsed disc was excised. The patient was discharged improved.

Roentgen examination in 1938 revealed several large globules scattered about the posterior half of the cranium, chiefly in the basal cisternæ and above the tentorium, apparently fixed.

Neurological examination in 1938 revealed no evidence of cranial nerve disturbance except that the left pupil was slightly larger than the right; both pupils were regular and reacted to light and accommodation. A review of his findings in October, 1937, prior to injection of the oil, revealed that the left pupil was also larger than the right at that time. There was atrophy and weakness of the muscles of the thighs and calves of the legs. The knee jerks were present and equal. The left ankle jerk was normal; the right was absent. No other abnormal reflex findings were noted.

This patient had intracranial collections of iodized oil for approximately 1 year. No cerebral symptoms or findings attributable to the presence of this oil could be detected.

Case 9. W. H., a 41 year old laborer, had 3 cubic centimeters of lipiodol injected into the lumbar subarachnoid space shortly before examination.

This case is mentioned merely to illustrate the fact that maintenance of the patient in Trendelenburg position following lumbar injection of lipiodol causes the oil to flow into the cranial cavity, and that one week later following maintenance of usual bed rest or ambulatory position, only a little of the opaque oil may remain in the cranium (Fig. 7). These facts are, of course, well known, but are occasionally forgotten, since fluoroscopic examination of the calvarium is not performed routinely following myelography. We have seen intracranial collections of iodized oil as early as 2 hours following lumbar myelography in patients who were not placed in Trendelenburg position at all, and who stated they merely lay in bed, denying any marked head down position. This observation is made merely to bring out the fact that a Trendelenburg position is not always necessary to permit oil entering the cranial cavity. However, in most cases, the oil is not visible in the cranium following simple bed rest.

SYNOPSIS OF REMAINING CASES

Case 10. N. S., male, aged 71 years. Intracranial iodized oil for 13 years. This patient had 10 cubic centimeters of lipiodol injected by the cisternal route in 1926, at which time he had symptoms strongly suggestive of spinal cord lesion. The large amount of lipiodol was used in error. At the present time he has large amounts of lipiodol scattered through the lower ventricles, basal cisternæ, and about the cerebellum. There is also a lake of about 5 cubic centimeters in the spinal cul-de-sac, still movable.

Case 11. J. D., male, aged 50 years. Intracranial iodized oil for 5 years. This patient had 3 cubic centimeters of lipiodol injected by the lumbar route in 1933. At the present time large amounts of lipiodol are scattered through the ventricles and basal cisternæ. No cerebral symptoms.

Case 12. A. C., male, aged 30 years. Intracranial iodized oil for 5 years. This patient had 3 cubic centimeters of lipiodol injected by the lumbar route in 1934. At the present time there are moderate amounts of oil in the basal cisternæ. No cerebral symptoms.

Case 13. L. L., male, aged 46 years. Intracranial iodized oil for 2 years. This patient had 3 cubic centimeters of lipiodol injected into the lumbar subarachnoid space in April, 1937. At the present time there are 6 large globules in the base of the skull and about the cerebellum, apparently fixed. No cerebral symptoms.

Case 14. M. P., male, aged 50 years. Intracranial iodized oil for 2 years. This patient had 3 cubic centimeters of lipiodol injected by the lumbar route in 1936. At the time of examination of the skull moderate amounts of oil were noted about the basal cisternæ and over the cerebellar lobes. No cerebral symptoms.

Case 15. M. W., female, aged 50 years. Intracranial iodized oil for 2 years. This patient had 3 cubic centimeters of lipiodol injected into the lumbar subarachnoid space in August, 1936. There are now 2 small droplets in the region of the lateral venous sinuses, apparently fixed. No cerebral symptoms.

CASE 16. R. K., male, aged 33 years. Intracranial iodized oil for 2 hours. This patient had 3 cubic centimeters of lipiodol injected into the lumbar subarachnoid space 2 hours previously; a posterior displacement of the right side of the fifth lumbar disc was discovered. The patient was not placed in Trendelenburg position, but, in spite of this, examination 2 hours later, following normal bed recumbency, revealed a few droplets in the region of the basal cisternæ and fourth ventricle, apparently movable. No cerebral symptoms.

SUMMARY

Our attention was called to the following facts: first, that iodized oil may be found scattered throughout the subarachnoid space over the cerebrum and cerebellum, in the basal cisternæ, and even in the ventricles years after its injection into the lumbosacral sac; and, second, that these collections might account for certain cerebral symptoms. In view of this, we studied a group of cases in which patients had had lipiodol injected at intervals of from 1 to 14 years. Approximately two-thirds of this group showed collections of varying amounts intracranially. A few of these patients, when re-examined, had symptoms and positive neurological findings indicating cerebral lesions. However, a review of the histories and neurological examinations previous to injection of the iodized oil showed the identical symptoms and findings except in one patient in whom, as noted above, the complaints could not be substantiated by objective findings, were made by a patient proved to be a malingerer, and have since disappeared, following a second spinal fusion; therefore, in our opinion, they must be disregarded.

The danger of drawing premature conclusions from the finding of iodized oil in the leptomeninges of the brain and spinal cord is well exemplified by Case 6 which came to autopsy. In this case it was at first thought that the lipiodol was responsible for many of the patient's symptoms and positive neurological findings. However, careful histological studies failed to reveal any cerebral or cord changes in the neighborhood of the oil and it is our opinion that these "lipiodol granulomas" have little or no clinical significance.

In our series of cases it was noted that the intracranial lipiodol tends to become fixed, that is, immovable, whereas iodized oil in the spinal canal, especially when in large collections, is sometimes freely movable even up to a period of 14 years following injection. Droplets tend to be fixed; collections of from 2 to 5 cubic centimeters movable.

Another observation of note was that the removal of the lipiodol at the time of laminectomy is extremely difficult. All of the cases in which operation had been performed carried notations that the lipiodol had been "aspirated at the time of operation." Subsequent roentgenological examination of most of these patients showed a surprisingly large amount remaining in the cerebrospinal canal.

So far we have no accurate explanation for the fact that only in two-thirds of the cases was the iodized oil found intracranially. Whether this is connected with the patient's occupation or postural habits, involving frequent lowering of the head, remains to be determined; we are now conducting an investigation into this phase of the problem.

CONCLUSIONS

1. Intracranial collections of iodized oil some years following lumbar myelography were found in approximately two-thirds of a series of 25 cases which we reviewed.

2. In no cases were there any symptoms or positive neurological findings which could be ascribed to the presence of the oil.

Since completion of this report, we have been informed that many leading neurosurgeons no longer incise the dura at laminectomy, in "disc and thickened ligament" cases, and leave the subarachnoid oil *in situ*.

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ANESTHESIA IN THYROIDECTOMY FOR THYROTOXICOSIS

W. H. COLE, M.D., F.A.C.S., and ROBBIE BRUNNER, M.D., Chicago, Illinois

A STUDY of the various phases of anesthesia in thyroidectomy leads to the conclusion that in general the choice of the anesthetic agent is relatively unimportant; a much more important feature is the skill of the anesthetist and his knowledge of the physiological principles related to anesthesia. It is probably true, from the standpoint of mortality, that in no other disease is greater judgment in determination of operability, time for operation, and extent of operation required than in thyrotoxicosis. Although it is apparent that any of several types of anesthesia may be satisfactory, it is no doubt true that a surgeon and his anesthetist should choose one or perhaps two of the major agents and use them as a routine. However, it is preferable that the anesthetist be experienced in use of all accepted agents so others may be tried if the agent commonly used fails.

Since it is true that the patients' hyperexcitability, elevated basal metabolic rate, increased cardiac strain, etc., are important factors in the smoothness of convalescence from operations, it is naturally obvious that the choice of a routine in anesthesia which diminishes these undesirable features will lead to the most satisfactory results. Important in this consideration is the fact that toxic goiter is associated with an increased oxygen consumption, thereby making it necessary that asphyxia be avoided at all costs during the period of anesthesia, particularly since the anoxia incident to asphyxia is so apt to increase the tachycardia, to put a severe strain on the cardiac reserve, and to elevate the blood pressure. Anoxia likewise causes congestion and increases the tendency to bleed, thereby adding to the surgeon's difficulties. It becomes imperative then that asphyxia be avoided during thyroidectomy.

It should be realized that the purpose of anesthesia in thyroidectomy for thyrotoxicosis is not only to avoid pain but to eliminate the psychic trauma mentioned. If the latter feature is taken care of, a great deal will have been accomplished toward lowering mortality. From the standpoint of idealism, it would be desirable to have an agent which would neutralize toxicity. From our knowledge at the present time this is impossible, unless depression of metabolism is equivalent to neutralization of toxicity. However, it must be realized also that the patient's inherent toxicity at the time of operation may be masked but probably cannot be neutralized with any type of anesthetic. Obviously, the mildly toxic patients will not sustain a sufficient amount of psychic trauma incident to the operation to do them any serious harm. It is in the severely toxic group that difficulties resulting in postoperative crisis, etc., will be encountered. A great deal of psychic trauma may be eliminated by adherence to the rule not to inform the patient of the time of operation except perhaps just at the time of operation. For years, Crile has emphasized the advantage of consulting the relatives, not the patient, concerning the operation, and performs the operation in the patient's bed. Crotti (6) likewise favors putting patient asleep in his bed but transports patient to operating room for the thyroidectomy.

If one of the gaseous agents—nitrous oxide, ethylene, or cyclopropane—is chosen, an attempt should be made to carry the patient in the lower border of the first plane of the third stage, representing the lightest degree of anesthesia which will abolish retching and vomiting, and yet allow the insertion of a pharyngeal airway. After this plane of narcosis has been obtained, it is our routine to insert a correctly curved pharyngeal airway whether or not obstruction has developed. An assured, clearly patent airway, however secured, is the principle upon which all good anesthesia is based. Absolute quiet and non-interference during the period of induction will in most cases eliminate the period of excitement, a complication to be avoided, particularly since safety in thyroid surgery is so dependent upon conservation of the patient's energy. The carbon dioxide absorption technique (Waters) aids in the maintenance of quiet, even respirations, and therefore should aid in the preservation of energy.

If ethylene or cyclopropane is used, the danger of explosions must be borne in mind constantly. Naturally, proximity of open flames, electric light switches, motors, etc., should be avoided. Of far more importance, however, is the danger of explosions from static sparks which may be created by contact of various objects including metal, clothing, etc., in the immediate environs of the gas

From the Department of Surgery and Division of Anesthesia, University of Illinois, College of Medicine and the Illinois Research and Educational Hospital. Read before the meeting of the American Association for the Study of Goiter, Cincinnati, May 22–24, 1939.

machine. It is essential that no loose connections, particularly metal, be permitted anywhere on the gas machine, but especially within the conduction system. During recent years static sparks have been responsible for practically all explosions. Still more important in the prevention of static spark than avoidance of loose connections, making and breaking contacts, etc., is the maintenance of a humidity of 55 or 60 per cent in the operating room. Thoroughly moistening the mask and rubber conduction system is likewise very essential. We subscribe to the conclusion expressed by Waters (18), that grounding of apparatus, floors, etc., will not diminish the hazard of explosions, but may increase it. Lahey has suggested an intercoupling device to equalize the electrical charge of the table, gas machine, etc., hoping that it will tend to minimize explosions.

Consideration of the *qualities desired in an anesthetic for thyroidectomy* reveals the obvious fact that none of the agents available fulfills all the requirements. It then becomes necessary to choose an agent or combination of agents which will meet as many of the following requirements as possible: (1) Minimize psychic trauma, (2) depress basal metabolism, (3) capable of rapid induction, (4) not elevate blood pressure or heart rate, (5) avoid anoxia, (6) minimize laryngeal spasm, (7) sustain quiet respiration, (8) be of relative low toxicity, (9) have a wide margin of safety, (10) conserve patient's energy.

PREMEDICATION

Well chosen premedication drugs with proper dosage are of great importance in establishing a smooth anesthetic for the primary anesthetic agent. The purpose of premedication is to lower the metabolic rate and to abolish psychic trauma. To be ideal, such drugs should not depress the respirations beyond a safe level. The effect of these drugs is dependent upon the degree of thyrotoxicosis; patients with severe toxicity require huge doses. Morphine is one of the most valuable of the pre-anesthetic drugs, acting directly as a metabolic depressant and indirectly by minimizing emotional excitement. Atropine is valuable in premedication because of its inhibiting effect on secretion of mucous membranes, but it stimulates metabolic activity. It is, therefore, losing favor as a pre-operative drug in thyrotoxicosis. It is being replaced by scopalamine which inhibits mucous secretion as does atropine; although it likewise acts as a metabolic stimulant, this action is largely neutralized by its reduction of emotional excitement. It is usually given in combination with morphine and when the two are balanced (dose ratio 1:25) induction of a general anesthetic is greatly facilitated. However, if the dose of scopalamine is too large, a restlessness and even a mild delirium may rarely result, to be corrected by an additional small dose of morphine or $1/64$ grain of apomorphine. From clinical experience we avoid the use of scopalamine in elderly, debilitated patients with thyrotoxicosis. Numerous routines are recommended for pre-operative drugs. Commonly, pentobarbital sodium (nembutal) 1.5 grains or phenobarbital (luminal) 1.5 grains is given the evening before operation and a hypodermic of $1/4$ grain morphine with $1/150$ grain scopalamine given 60 minutes before operation the next morning. A dose of 1.5 grains of pentobarbital about 90 minutes before operation may aid in allaying apprehension and excitement and thereby allow the patient to take a better anesthetic. Sise (16) prefers 3 grains sodium pentobarbital by mouth $1\frac{1}{2}$ hours before operation, followed by a hypodermic of $1/8$ grain of morphine and $1/150$ grain scopalamine about 45 minutes before operation (preceding cyclopropane anesthesia).

Of the group of drugs recommended as a basal anesthetic preceding general anesthesia, avertin, paraldehyde, and sodium amytal are most commonly used. Avertin which is most popular is discussed in detail later. Because paraldehyde has very little depressant effect on respiration or the circulation, and has a wide margin of safety, Marston has adopted it to precede nitrous oxide anesthesia: he gives 1 dram rectally for each 14 pounds of body weight 45 minutes before operation. Crile and Adams, however, have reported a high incidence of pneumonia following paraldehyde; this complication is to be expected since the drug is eliminated by way of the respiratory system. Sodium amytal is rarely used as a basal anesthetic because of a toxicity greater than avertin given in doses sufficient to produce unconsciousness.

LOCAL ANESTHESIA

Although many surgeons use local anesthesia as a routine in thyroidectomy, there is a far greater number who criticize it because of the severe psychic trauma which will be inflicted on the highly toxic patient during the operation. Perfect premedication is perhaps more essential with local anesthesia than with any other type. Unfortunately it cannot always be obtained because of difficulty in determining toxicity, variability of individual reaction, etc. A small series of cases studied by Brunner and Seed, in which premedication might be considered inadequate, revealed an elevation of the pulse rate during operation to

nearly 130 beats per minute, although the patients were only mildly toxic, and uncomplicated by hypertension or cardiac damage. Premedication so liberal as to secure mental tranquility may produce a depression greater than would have been exacted by the use of general anesthesia at the outset. To counteract psychic trauma, surgeons using local anesthesia rely upon various types of premedication. Hertzler has adopted a routine giving 4 grains of amytal the evening before operation and an additional 3 grains at six in the morning; an hour before operation the patient is given 1/6 grain of morphine.

One of the great advantages of local anesthesia is the fact that as an anesthetic agent it is probably less toxic than any other anesthetic. The difficulty in eliminating the patient's apprehension and the slight inconvenience inflicted upon the surgeon, to a great extent neutralizes this advantage. The one definite indication for local anesthesia is obstructive dyspnea of such a nature that intubation is not feasible.

Although numerous modifications are utilized in infiltration of the procaine (½ to ¾ per cent), the principles are relatively the same. Pinching the skin gently for a moment before inserting the first needle will minimize the pain. The skin is infiltrated along the line of incision and then subcutaneously under the skin flap, but more particularly in the lateral directions to block the branches of the cervical nerves as they loop around the sternomastoid muscle. It is usually desirable to infiltrate the strap muscles so that they may be retracted without discomfort. A few cubic centimeters may likewise be injected into the upper pole and in the neck between the upper pole and trachea. Brenizer resorts to a more regional type of block by injecting laterally at the posterior border of the sternomastoid delivering procaine particularly at the sixth and second transverse processes.

Adrenalin should not be used with procaine (novocain) for thyroidectomy, because of the tendency to elevate blood pressure and likewise because of the possible relationship of adrenalin to ventricular fibrillation (Guedel). This condition may account for sudden death during operation, particularly in the patients who are greatly frightened.

Zellhoefer made a study of the healing of wounds after thyroidectomy in patients having a regional block on each side of neck, compared to the healing in patients having a local infiltration from the front. He concluded that healing takes place more smoothly when actual site of operation is injected with little or no anesthetic solution.

Sise (17) advises against local anesthesia, particularly in thyrocardiac patients because he has observed "venous congestion definitely to increase during operative procedures" during local anesthesia.

NITROUS OXIDE

Previous to the introduction of ethylene and cyclopropane, nitrous oxide was a popular anesthetic for thyroidectomy in thyrotoxicosis. Anesthesia with nitrous oxide permits an oxygen content in the gaseous mixture of less than 10 per cent, thereby tending to create a deficiency in a patient who needs a particularly large amount. Since cyanosis is so harmful to thyrotoxic patients and yet so difficult to prevent, a great many anesthetists and surgeons resorted to the use of ethylene or cyclopropane when these agents became available. Numerous workers have called attention to the tendency toward reduction of the alkali reserve following nitrous oxide anesthesia. With care in prevention of anoxemia, this phenomenon can be minimized.

Nitrous oxide is still being used by the majority of anesthetists in England, and by many anesthetists in this country. Waters (19) and associates favor nitrous oxide, but change to other agents as indicated. It is probably correct to state that to give nitrous oxide harmlessly in thyroidectomies for thyrotoxicosis requires enviable skill and experience.

From many standpoints nitrous oxide is a very desirable anesthetic. In the first place, it is noninflammable—a feature possessed only by a few of the anesthetic agents. Since the maximum depth of anesthesia attainable even with adequate sedation is probably no greater than slightly below the middle of the first plane of the third stage, it is relatively harmless from the standpoint of actual toxicity through depth of anesthesia. Cyanosis, which is perhaps the greatest drawback to nitrous oxide anesthesia may occasionally be corrected by more premedication. More commonly, the anesthetist may change to a more potent agent, thus allowing more oxygenation.

ETHYLENE

It is possible to attain a depth of anesthesia down to the lower border of the first plane of the third stage with ethylene. This can be maintained with the maintenance of an oxygen mixture between 10 and 20 per cent. Toxicity of ethylene, as in nitrous oxide, is dependent upon oxygen deficiency, but with well timed premedication anoxia can be avoided. A disadvantage is the fact that it forms a violently explosive mixture with oxygen. We prefer premedication to consist of

morphine and scopalamine. Thus a toxic thyroid patient might receive 90 minutes preceding surgery, 1/6 grain morphine, 1/150 grain scopalamine to be followed in 30 minutes with 1/8 grain morphine. This dose is, of course, varied, depending upon toxicity and the general condition and age of the patient. If desired, 1.5 to 3 grains pentobarbital (nembutal) may be given 2 hours before operation, in which case the dose of morphine and scopalamine should be decreased.

CYCLOPROPANE

This agent was introduced in 1929 by Lucas and Henderson. Much of the pioneer work in its pharmacology was done by Waters and Schmidt (21), who did a great deal to popularize its use. In spite of a huge number of reports available in the literature regarding the use of this agent, there are still innumerable points about which there is a total disagreement. One of the great advantages of the gas, particularly in thyroidectomies, is its potency, which allows a large percentage of oxygen to be given. Six per cent or less of cyclopropane is sufficient to cause unconsciousness in the average individual (Seevers, 14, and associates). Anesthesia can be carried all the way through the third stage with a percentage no greater than 20 or 25 per cent cyclopropane. Induction is pleasant, there being no irritation to the mucous membranes unless the gas is used in concentrations greater than 50 per cent. The fact that respiratory failure occurs before cardiac failure fulfills one of the prerequisites of a safe anesthetic. The pharmacology and action of cyclopropane is reported by American Medical Association's Council on Pharmacy and Chemistry (13).

There is no agreement as to whether cyclopropane is more apt to produce laryngospasm, shock, and circulatory collapse (factors particularly important in thyroidectomies) than other gases. It is well known, however, that bradycardia, arrhythmia, and tachycardia may be produced by the gas; the latter feature would, of course, be particularly detrimental in thyrotoxicosis since the patient is already suffering from tachycardia. Waters and Schmidt (21) warn that bradycardia and tachycardia are in reality expressions of overdosage and would, therefore, be inexcusable in thyroidectomies, since deep anesthesia is not needed in this work. In spite of the possible deleterious effect on the cardiac mechanism, Sise has expressed himself as favoring cyclopropane slightly over ethylene and to a great extent over local and nitrous oxide in thyrocardiac patients, because of the advantage cyclopropane affords in its ability amply to maintain oxygenation.

One of the disadvantages of cyclopropane is the apnea and even acapnia which may be associated with its use. The fact that the gas is not a respiratory stimulant is partly responsible for these features. The usual signs of anesthesia, described and recently standardized by Seevers and Waters (15), are not of great use in cyclopropane anesthesia because of its peculiarities. Changes in heart rate as here mentioned may be the most reliable indication of a deep anesthesia. Movements of the eyeball are of only slight import in determining depth of anesthesia. Intercostal activity is of more value. In a large series of patients Waters (20) noted that nausea and vomiting occurred in 36.5 per cent of ether cases, 39 per cent of cyclopropane, 33 per cent ethylene, and 23 per cent of nitrous oxide cases. This relatively high frequency of nausea and vomiting constitutes a definite disadvantage in thyroid surgery because of the tendency of retching and vomiting to encourage postoperative hemorrhage. Some of the inability to standardize the various features in cyclopropane anesthesia may be due to the fact that in this gas at present time are a great many impurities many of which could not be classified as non-toxic. The highly explosive character of cyclopropane is an obvious disadvantage.

Because this agent is not a respiratory stimulant, many anesthetists and surgeons consider premedication drugs to be harmful since most of them actually act as respiratory depressants. This contra-indication to the use of premedication would appear to act as a disadvantage for cyclopropane in thyrotoxicosis, because it is so highly desirable to eliminate psychic trauma by premedication. In spite of the apparent danger of premedication with cyclopropane anesthesia, Sise (16) has noted no deleterious effects and recommends sodium pentobarbital (nembutal), 3 grains by mouth 1½ hours before operation and 1/8 or 1/6 grain morphine with 1/150 or 1/200 grain scopalamine, 45 minutes before operation. Many anesthetists and surgeons including Sise (16), Goetsch, and others, use cyclopropane in thyroid surgery almost exclusively. Because of the numerous points of disagreement regarding the action and effect of cyclopropane, it is obvious that this agent should be used in thyroid surgery only by those highly trained in anesthesia as well as in the use of cyclopropane.

AVERTIN

Of the numerous basal anesthetics available, avertin is unquestionably the most popular and probably the safest. It is given rectally 25 to 30 minutes before operation in doses between

0.07 and 0.1 gram per kilogram, the dose being varied slightly with the toxicity of the patient. This dosage is sufficient to cause the patient to go to sleep, but naturally does not abolish pain; supplemental anesthesia is therefore required. Patients can usually be aroused after this dose but rarely remember incidents occurring during this period. Avertin lowers metabolic activity as well as blood pressure; both of these qualities are desirable in thyroid surgery. It is a respiratory depressant, and therefore might be an undesirable premedication in thyrocardiac patients in whom there is already difficulty in maintaining proper oxygenation. Since it is a respiratory depressant, many workers condemn or caution against the use of morphine with it. In analyzing 9 deaths in the literature following avertin, Heard noted that all except one had had morphine and finally concluded that morphine may have been an important factor in this death. If morphine is to be used, Heard recommends giving only .09 gram avertin per kilogram of body weight.

As is the case with premedication and anesthetic agents, avertin is used throughout the country in innumerable combinations with other agents. Keynes uses it as basal anesthetic preceding local anesthesia but not infrequently resorts to nitrous oxide before completion of operation.

An advantage often ascribed to the use of avertin in thyroid surgery lies in the fact that it decreases oxygen consumption and requires less of the accessory anesthetic agent. Heard noted that a mixture of 60 per cent nitrous oxide and 40 per cent oxygen was ample to maintain anesthesia after avertin. It has been our clinical observation that the decrease in minute volume of respiration produced by avertin tends toward a state of anoxia; measures must be taken to prevent this.

Experimental observations made by Arnheim and Tuckman (1) with avertin (0.1 gram per kilogram) in normal persons (not having operations at that time) should be very helpful in evaluating the disadvantages or advantages in thyroid surgery. They studied the reaction in 15 people, without premedication or supplementary anesthesia, and averaged the findings. They noted a drop of 24 millimeters in blood pressure and a drop of 22 per cent in the basal metabolic rate. The respiratory rate increased 6 per minute, but there was a decreased amplitude. The pulse rate increased 16 beats per minute, a finding which was borne out in our own studies with thyrotoxic patients during operation. Arnheim and Tuckman noted also that there was a drop of 1.8 degrees F. in rectal temperature and a reduction of 3 minutes in the clotting time. There was slight cyanosis in 2, and slight vomiting in 3 of the patients. The production of tachycardia and the occasional occurrence of cyanosis and vomiting would therefore be detrimental in the use of the agent as a basal anesthetic in toxic goiter. These defects probably more than neutralize the beneficial effects which might be ascribed to the drug as deducted from their experiments.

The fact that patients receiving .09 to 0.1 grain avertin per kilogram may be practically unconscious for 2 or 3 hours following operation may be an advantage or disadvantage in thyroidectomies depending upon circumstances. If the patient is in a charity hospital where nursing facilities and oxygen therapy may be inadequate, such complications as vomiting, respiratory obstruction, etc., may result in serious consequences. On the other hand, if the patient is particularly apprehensive and is able to have a private nurse, the abolition of memory during the first few postoperative hours will be a decided advantage; with adequate nursing care the dangers incident to vomiting and pharyngeal obstruction during the 2 or 4 hour period of semi-consciousness after operation will be minimized.

Clinical observation. In an attempt to evaluate avertin as a basal anesthetic in thyroidectomy for thyrotoxicosis we conducted a study in which we used avertin in 100 thyroidectomies. This series was almost evenly divided between toxic diffuse goiter and toxic nodular goiter. Dosage ranged from 60 to 90 milligrams per kilogram body weight, the average dose being 71.8 milligrams. All patients were premedicated. This consisted of 15 grains pentobarbital (nembutal) the evening before surgery and at 6 o'clock the next morning. A hypodermic of 1/6 to 1/4 grain morphine sulphate and 1/150 grain of atropine was given one hour preceding surgery with no regard for time of avertin injection. In 4 cases this injection was given 20 minutes following the injection of avertin. No further fall in blood pressure or increase in respiratory depression was noted. Of the 100 patients observed 88 were asleep on reaching the operating room. These responded to external stimuli, but slept quietly when undisturbed. Eight patients were not asleep, but were drowsy, quiet, and co-operative. Four patients were mildly talkative, but showed no apprehension or rise in blood pressure. In these 12 cases the course of anesthesia was smooth. The average time interval between the injection of avertin and the surgical incision was 39 minutes. In all cases avertin anesthesia was supplemented with ethylene except for 11 cases in which nitrous oxide was

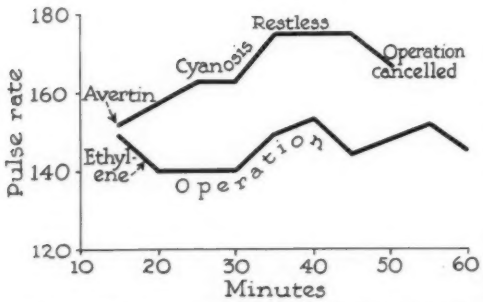

Chart 1. The upper graph represents the pulse rate of Case 1 after being sent to the operating room after avertin (70 milligrams per kilogram). Under observation the patient's pulse rate, cyanosis, and restlessness increased; operation was therefore cancelled. The lower graph illustrates the pulse rate during operation under ethylene, without avertin, 4 weeks later. The pulse rate revealed practically no rise; convalescence was relatively uneventful. Comparison of the two curves indicates that avertin detracted markedly from the patient's operability.

used. In no case was the preliminary incision made under avertin anesthesia alone. Approximately the same interval elapsed between the induction of gas anesthesia and the beginning of surgery as in cases in which avertin was not used.

Perusal of the changes in blood pressure and pulse in patients having thyroidectomy for toxic goiter (about equal number toxic and diffuse) reveals a definite tendency for avertin to prevent the increase in blood pressure which is so commonly noted in thyroidectomies without avertin (Table I). In each series ethylene was the anesthetic used except in a few instances when nitrous oxide was used.

The average elevation of the systolic blood pressure from the pre-operative level (on the ward) to the level of the average during operation in the group not having avertin was 17 millimeters. In the patients having had avertin, there was actually a drop of 3 millimeters showing that the tendency toward lowering of the blood pressure by avertin was equal to 20 millimeters. The pre-operative pulse (on the ward before coming to the operating room) rose from 93 to 109 in the non-avertin group, whereas it rose from 100 to 122 in the avertin series. The pulse rise was, therefore, 6 beats more in the avertin series than in the non-avertin series. This would indicate that perhaps a slight load was inflicted on the cardiac mechanism by the avertin. The pulse pressure in the non-avertin series was 56 before operation, and 63 during operation; in the avertin series the pulse pressure was 73 before operation, and was reduced to 67 during operation. This

TABLE I.—EFFECT OF AVERTIN ON BLOOD PRESSURE AND PULSE

	Systolic blood pressure			Pulse		
	Pre-op.	Oper.	Rise	Pre-op.	Oper.	Rise
No avertin 321 cases	130	147	17	93	109	16
Avertin 100 cases	148	145	−3	100	122	22

indicates that avertin exerts a definite tendency to decrease the pulse pressure. All of the readings on blood pressure and pulse used in arriving at the figures quoted represented an average of 12 readings taken at 5 minute intervals beginning with induction of the anesthesia. Additional studies were made of the patients after operation. From the standpoint of pulse rate, temperature, length of hospitalization and complications, avertin appeared not to have the slightest effect on the postoperative course. In one of the few severely toxic cases in our series, protocol given below, avertin appeared definitely to produce detrimental effects including cyanosis, restlessness, depression of respiratory system, and elevation of pulse rate, thereby decreasing operability.

CASE 1. A white man, aged 28 years, No. 51521, had a severe toxic goiter, and a right lobectomy had been performed August 19, 1936. In spite of bed rest, iodine, sedatives, etc., he failed to show any improvement or period of remission. On October 16, 1936, he was given ¼ grain morphine and 1/150 grain atropine followed by 70 milligrams avertin per kilogram preparatory to removal of the second lobe. Upon arrival in the operating room he was restless, breathing rapidly, and cyanotic. Pulse rate was between 140 and 150 (Chart 1) but the blood pressure was only 140, the same as on the ward. During a short period of observation, the pulse rose to 174 and restlessness as well as other symptoms increased. One of the most alarming features presented by the patient was a definite cyanosis, resulting no doubt from the respiratory depressant effect of the avertin. The patient was obviously a very poor operative risk, and the operation was cancelled. The patient recovered to his original condition after the avertin wore off but still remained severely toxic. On November 15, 1936, he was sent to the operating room again, receiving ¼ grain morphine and 1/150 grain atropine, 1 hour before operation and 1/6 grain morphine, 30 minutes before operation which was done under ethylene anesthesia. He was fairly composed this time and revealed no cyanosis. The pulse rate ranged from 138 to 145 although the blood pressure was elevated to an average of 170/70. The remaining lobe was removed uneventfully, the blood pressure dropping constantly during operation until at completion of operation it was 140/58. The pulse remained unchanged at about 140, throughout the operation.

It appears quite definite, therefore, that avertin detracted sharply from this patient's operability. Similar cases have been reported (Keynes) in which avertin appeared to aggravate the toxicity. Such a disadvantage, although uncommon, is of

extreme importance because operation in these instances may lead to a fatality. We grant that the dose of avertin in the case cited may be subject to criticism since even though reinforced by ¼ grain morphine, only 70 milligrams per kilogram were given. We scarcely believe that a greater dose of avertin would have improved his operability since he was already showing the effect of severe respiratory depression. Even if we grant that in this instance a larger dose of avertin would have made him a better operative risk, this disadvantage of avertin still remains as an acute one because it is so difficult to approximate accurately the degree of toxicity. It is well known that not infrequently the basal metabolic rate readings are grossly misleading and just as well known that even the best clinicians cannot accurately estimate the degree of toxicity in all cases because of atypical manifestations which may be of conflicting character.

In answer to the possible criticism that the dose of avertin in Case 1 was too small, the following case is cited.

CASE 2. A white female, aged 41 years, had a lobectomy for a severe toxic diffuse goiter and returned for removal of the second lobe on December 10, 1936. Her pulse ranged between 88 and 120. Her weight was 114 pounds. Premedication consisted of 1.5 grains pentobarbital the evening before and this was repeated 2 hours prior to surgery; 1/6 grain morphine, 1/150 grain atropine, was given 1 hour before surgery. Avertin was given on the basis of 70 milligrams per kilogram. The patient fell into a light sleep and mumbled occasionally, 40 minutes after the injection of avertin, the patient having been at rest in the meantime (with an anesthetist present). The pulse had risen from a rate of 120 to 160. Blood pressure had dropped from 145/80 to 120/60. Ethylene anesthesia was then induced, but since the pulse rate decreased only to 140 beats per minute, operation was deferred. The patient returned for surgery on January 21, 1937, having gained 11 pounds. Her basal metabolic rate was plus 56. The pulse had been running between 80 and 90, but the evening before operation reached 130. Premedication was the same as previously save that morphine was increased to ¼ grain. Avertin was given on the basis of 100 milligrams per kilogram. At this time the blood pressure was 164/60; pulse, 132. Before inhalation anesthesia, the blood pressure had fallen to 122/50 with a pulse rise to 150. No restlessness was recorded and the induction of ethylene anesthesia was entirely smooth. Ten minutes later the incision was made. The plane of anesthesia at this time was recorded as second plane of surgical anesthesia. Five minutes after the incision was made the blood pressure rose to 220/70 and the pulse rate increased to 168. The airway was entirely clear. The plane of anesthesia was lowered by the addition of ether vapor for less than 5 minutes. Respirations had been even in amplitude and rate, and now rose to 30 per minute with no evidence of oxygen want or carbon dioxide accumulation. The pressure continued to rise for the next 15 minutes when the blood pressure was 230/50; pulse, 180. At this reading the gland was recorded as "taken out." Within 5 minutes the blood pressure fell to 200/70, but the pulse remained 180. The operative procedure required 50 minutes and at the end the blood pressure was 200/62; pulse, 180, plane of narcosis, lower first. The postoperative course was "unusually uneventful."

In this case it will be noted that in spite of the dose of 100 milligrams avertin per kilogram, the blood pressure rose to 230, with a maximum pulse rate of 180. This severe reaction occurred in spite of the fact that the patient had gained 11 pounds since the previous admission when operation was cancelled following a dose of 70 milligrams avertin per kilogram. In other words, her operative risk appears not to have been improved by the large dose of avertin. The fact that the patient had so smooth a convalescence also casts some doubt as to whether the patient really was as toxic as the course during operation would indicate.

Value of avertin in thyroidectomy. Although we are of the opinion that the disadvantages of avertin outweigh the advantages it should be stated that many workers (Heard, Keynes, and others) are in favor of the use of avertin as a basal anesthetic in thyroidectomies. In our own experience we noted a few deleterious but no dangerous effects from the use of avertin in the group of mildly toxic patients. It is possible that in this group the elimination of apprehension and worry by the unconsciousness may more than neutralize any ill effects, particularly in the private patient who is unduly apprehensive. However, in a charity hospital where nursing service is inadequate, serious accidents (such as aspiration of vomitus, obstructed airway, etc.) would be more apt to develop after operation following anesthesia combined with a basal anesthetic even in the group of mildly toxic patients because of the prolonged state of unconsciousness. The decrease in operability mentioned previously may be encountered in the severely toxic group in either the private or charity patient, and becomes an extremely important disadvantage. Unless exceptionally astute judgment is exercised in this group, a fatality may ensue.

Table II reveals more disadvantages than advantages in the use of avertin. Such features as depression of the respiratory system, reduction of operability in occasional instances, and toxic effects on various organs along with less important disadvantages, would appear to outweigh the advantages. It is agreed that the drug is detoxified or conjugated by the liver and is excreted in one form or other by the kidney. This process adds a load on the human organism which a gaseous agent does not.

Fatalities produced directly by avertin are relatively common. In a series of 3,934 cases in

TABLE II.—EFFECT OF AVERTIN ON THYROIDECTOMY

Advantages	Disadvantages
1. Decrease basal metabolic rate	1. Depress respiratory system (decrease minute volume respiration)
2. Decrease the rise in blood pressure	2. Encourage cyanosis
3. Abolish psychic trauma	3. Increase pulse rate
4. Less supplementary anesthetic required	4. Toxicity on liver and kidney
	5. More postoperative care required
	6. Occasionally encourages vomiting
	7. Occasionally reduces operability in the severely toxic patient
	8. Anesthetic deaths more frequent than with any other popular agent

which avertin was given at Massachusetts General Hospital, Beecher reports 7 deaths. This is classified by him as being a higher death rate even than the rate in chloroform anesthesia.

COMPLICATIONS

There are innumerable anesthetic complications which may arise during thyroidectomy; many of these are the fault of the surgeon and not the anesthetist. Perhaps the most common is *obstruction*; this is rarely severe enough to cause alarm, except that even slight obstruction may lead to *anoxemia*, a condition which is highly undesirable in thyroidectomies for toxic goiter because of the deleterious effect on the myocardium and of the tendency to increase hemorrhage and elevate the blood pressure. In most instances, obstruction will be of pharyngeal origin and can be corrected readily by adjusting the jaw and insertion of an airway. Not infrequently *laryngeal and tracheal spasm* will be the cause of the obstruction. This complication apparently may develop with almost any of the inhalant anesthetics; it is of reflex origin and caused by numerous factors (Cole, 4) including too light anesthesia, starting the operation before proper anesthetic depth is attained, certain operative manipulations, particularly about the superior pole, and too sudden increase in concentration of the anesthetic agent. If these factors are borne in mind, the spasm will usually be readily corrected, particularly if the surgeon stops operating and relieves all possible sources of pressure and tension. On rare occasions tracheal intubation will be necessary. A much more serious cause of airway obstruction is that produced by *cord paralysis*, created usually by operative trauma. Paralysis of one cord only will produce a variable amount of obstruction, depending somewhat upon whether or not a spasm develops in the unaffected cord. If both cords are involved obstruction becomes so acute that tracheotomy may be necessary even before the operation is completed. If obstruction is caused merely by pressure of a clamp, removal of the offending clamp may eliminate the difficulty. Commonly it will be difficult to determine on the spur of the moment whether obstruction is caused by laryngeal spasm or cord paralysis. On such occasions intubation will usually be the procedure of choice. When the tracheal tube is removed, the surgeon should be available to do a tracheotomy if the airway cannot be re-established because of cord paralysis. Obstruction may, of course, be produced by rough handling of the gland, particularly if a large adenoma is located behind the trachea. Care in operative technique will eliminate this obstruction unless there is an actual atrophy of several of the cartilaginous rings. All patients should be questioned closely before operation as to the possible presence of obstructive symptoms produced by pressure of the gland, and x-ray films taken to determine the location of the trachea. If there is evidence or a significant history of obstruction, it will usually be preferable to intubate the patient after the anesthetic is started but before the operation is begun. Cyclopropane is of great value in affording anesthesia of sufficient depth for this procedure. Sise and Lahey have found helium to be helpful in minimizing the mechanical factor of obstruction.

The average patient with thyrotoxicosis does not tolerate very well the drop in blood pressure which follows *hemorrhage*. If, for some reason, hemorrhage has been profuse, measures, such as transfusion or intravenous glucose, should be taken early to maintain blood pressure.

Although *pneumonia* has been mentioned as a complication, it is extremely rare; we have encountered it only once in over 500 thyroidectomies.

SUMMARY

Because of its failure to abolish psychic trauma local anesthesia is criticized by most surgeons and anesthetists as being unsuitable in operations for toxic goiter unless premedication has been perfect. In the severely toxic patient it would not appear possible to eliminate this psychic trauma, even though premedication is ideal. Ether is rarely used because of the irritation to the respiratory tract and because surgical relaxation is not necessary in thyroidectomy. The gases, nitrous oxide, ethylene, and cyclopropane, are the most popular of the anesthetic agents. The

former is a desirable agent, but requires great skill in the art of anesthesia to prevent anoxemia which is so harmful to the thyroid patient.

Exceptionally effective premedication is essential in the safe conduct of nitrous oxide anesthesia. Cyclopropane is the latest of the popular agents, is sufficiently potent to allow a very high oxygen content, but has the slight disadvantage of not being a respiratory stimulant and of producing changes in the cardiac mechanism when the toxic dose is approached. This is particularly confusing and undesirable in patients with auricular fibrillation or significant tachycardia.

Ethylene is sufficiently potent when preceded by adequate and well timed premedication to allow anesthesia without oxygen want and is not toxic; it is probably as safe as any agent for the average anesthetist. We prefer it to all other agents. As a premedication to the gaseous agents, ¼ grain morphine and 1/150 grain scopalamine, varying dosage with toxicity, given 60 to 90 minutes before operation should be as effective as any. Sodium pentobarbital (nembutal) in doses of 1.5 grains may be given 30 to 60 minutes before the hypodermic injection of morphine and scopalamine, the dose of which may then be reduced slightly.

Avertin is the most valuable of the basal anesthetics but never should be given in doses large enough to permit the operation to be performed without another anesthetic agent. The total abolition of the apprehension which might produce psychic trauma, the tendency to prevent elevation of blood pressure, and the decrease in basal metabolic rate incident to avertin anesthesia, are advantages in favor of the use of the drug, but do not neutralize the serious defects of respiratory depression, etc. (see Table II). Occasionally, avertin may aggravate symptoms of toxicity, creating such a strain on cardiac reserve that operation may be fatal. If avertin is used, extreme care must be utilized in recognizing these instances and postponing operation. After analyzing our clinical experiences with avertin, we came to the conclusion that the disadvantages outweighed the advantages particularly because the drug appeared occasionally to aggravate toxicity in the severely toxic group of patients.

It should be emphasized that there is such a slight difference in the efficiency of the various anesthetic agents that good results may be obtained with any of those mentioned if care is used in its use, and work is confined to one agent to such an extent that the anesthetist and surgeon become well acquainted with its deficiencies. If a given anesthetic fails, the anesthetist should be prepared to resort immediately to another with the hope of eliminating the difficulty. One of the most important complications to be avoided is cyanosis.

Regardless of the agent used, it is extremely important that the anesthetist and surgeon cooperate fully in their effort to avoid operation on patients at a time when the patient's condition is too precarious because of toxicity, cardiac disease, etc., or his pre-operative preparation too inadequate to permit operation safely.

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OVARIAN AUTOGRAFTING FOR ENDOMETRIOSIS

VIRGIL S. COUNSELLER, M.D., F.A.C.S., and DONALD H. WRORK, M.D.,
Rochester, Minnesota

THE ravages of endometriosis in the pelves of women confront the surgeon with difficult problems in judgment and method. If the pelvic structures are bound in the cul-de-sac of Douglas by dense adhesions and if the symptoms are severe, there are two surgical alternatives for arrest of the disease: (1) either postoperative irradiation of sufficient intensity to suppress permanently ovarian function, or (2) removal of the ovaries.

After either of these procedures, the surgical menopause promptly ensues, and for a high percentage of patients it is accompanied by distressing symptoms. Ovarian autografting is an uncommonly employed approach to the problem, the usual procedure being to rely on the administration of estrogenic preparations for control of the menopausal symptoms. Autografting has not been widely employed (11) in the treatment of endometriosis because of the general knowledge among surgeons that so long as diseased ovarian tissue is present *in situ*, seeding of the pelvic peritoneum occurs with progression of the disease. However, if the organs can be surgically separated, replaced, or removed, and all the sources of reimplantation can be eradicated, the estrogenic hormone may be present in the body without causing severe symptoms. If the structures are fused inextricably, if the symptoms are severe, and if the risk of damage to the sigmoid and ureters is grave, irradiation is the simplest solution.

But when the pelvic organs and the diseased tissues can be removed, and fragments of normal appearing ovary are available, autografting is indicated. The procedure has produced satisfactory results in the treatment of 4 of 5 patients so treated. By means of this procedure, the disease can be arrested and ovarian function preserved with a negligible possibility of recurrence of symptoms and consequently, need for subsequent laparotomy.

TECHNIQUE

The technique of autografting of ovarian tissue employed by most surgeons has been that described by Tuffier in 1910, and most operations (121) of this series of 136 have been done by this method. It is performed by preparing, by blunt dissection, a site in the abdominal wall close to the incision. All bleeding points are carefully ligated. Into this bed is inserted the largest available fragment of normal appearing ovary. Because of the fact that the percentage of successes obtained by this type of procedure in the hands of many surgeons has been low, the procedure for autograft has fallen into disuse. Microscopic studies made elsewhere on Tuffier grafts which had been removed while they were still functioning have demonstrated necrosis of their centers, the functioning tissue being confined to a narrow peripheral zone.

Since 1936, 15 patients have undergone the operation for autograft at The Mayo Clinic by the method of multiple implantation; the sites for the implantation of the grafts have been prepared as previously described. Five patients had endometriosis and 10 had oophoritis. Those portions of the ovaries which were free from disease were implanted after they were shaved into thin sections instead of being used in the form of segments. Two-thirds of the grafts for this group of 15 patients were successful.

ANALYSIS OF RESULTS

Autografting of ovaries is an old procedure. Authors whose contributions have been of considerable value are listed in references 1–10. Since it was first indexed at The Mayo Clinic in 1915, it has been performed for 136 patients, an average of about 6 operations a year for the 24 years. Table I shows the pathological states for which the autografting was done.

Follow-up data sufficiently complete to determine the fate of the autografts is available for 68 patients, or one-half the group of 136 patients. Thirty grafts, or 44 per cent of those performed, were successful; 38 grafts, or 56 per cent, gave no evidence of activity as reported by letter by the patients concerned.

Any one of four criteria were accepted as evidence of a successful graft: (1) relief of hot flushes with evidence of growth of the graft; (2) formation of a node at the site of the autograft manifesting a monthly enlargement; (3) periodic recurrence of menstrual molimina; or (4) menstruation, if the uterus was not removed.

From the Division of Surgery, The Mayo Clinic and The Mayo Foundation.

TABLE I.—ANALYSIS OF 136 CASES OF AUTOGRAFTING OF OVARIES

Condition	Patients	Per cent	Patients traced	Per cent	Activity of autograft			
					Success	Per cent	No success	Per cent
Cystic, inflammatory ovaries	109	80	68	50	30	44	38	56
Endometriosis, tarry or chocolate ovarian cysts	15	11						
Tuberculosis of pelvic organs (not ovaries)	2	1.5						
Anomalies of pelvic organs, dysfunction	2	1.5						
Benign tumors of ovaries	2	1.5						
Not stated	6	4.5						
Totals	136	100						

The average time that elapsed before there was evidence of activity of the grafts was 5 months. Vasomotor waves were observed of a high percentage of patients during this interval, but they disappeared with the first enlargement of the graft. Preservation of a menstrual rhythm has been noted in the patients who were successfully treated, characterized by the coincident enlargement of the nodes and the occurrence of the usual menstrual molimina; this activity did not depend on whether or not the uterus had been totally removed. For the usual patient the nodes began to enlarge about 7 to 10 days before the date of onset of the expected menstrual period.

For women who have undergone successful autografts and from whom the uterus has been removed, the symptoms marking the menstrual time are usually brief. In most instances the length of the cycle has remained at about 1 month, although for a few patients it has become lengthened to 2 or 3 months.

The possibility of subsequent formation of cysts has long been a deterrent to the operation of autograft. Of 83 patients concerning whom data on this point were available, cysts of the grafts probably afflicted three. The largest of these cysts was described by the patient as being the size of a hen's egg; it persisted for 3 months. The relatively minor operation of removing an extraperitoneal autograft because of prolonged and painful enlargement was required for only 1 patient. Aspiration of such a cyst is usually sufficient to prevent excessive enlargement. No case of endometriosis of the site of the graft has been encountered thus far.

The average age of the group of 136 patients was 35 years. For the group of patients for whom the procedure was successful, the average age was 31 years, while for the patients who reported no evidence of activity of the graft, the average age was 37 years.

Grafts have been placed between the peritoneum and the transversalis fascia, in the rectus abdominis muscle, above the sheaths of the recti muscles, and for one patient, on each cornu of the uterus. No evidence was uncovered in the course of this study to indicate that one site is superior to another for implantation. It is probable that grafts placed in rectus abdominis muscle are more tender than are those placed elsewhere, because of the mobility of that structure.

Data on the length of time elapsing before the appearance of the node are available concerning 9 patients; the average length of this interval was 5.3 months. Information as to the length of time elapsing between the operation and the onset of menstruation is available for only 2 patients; it was 4 months for 1 patient, and 5 months for the other.

The length of life of the graft is difficult to determine because data obtained by letter are often equivocal, because many of the most promising grafts are still functioning, and because data on all patients are not available. Some grafts have functioned for only 4 or 5 months, whereas 3 grafts have functioned 10 years or longer (10, 12, and 15 years). The average duration of activity of the grafts for 9 patients concerning whom accurate information is available was 5 years. Attention should be given to the fact that failure of viability of the graft does not mean that the operation was not beneficial, since most patients of this group were relieved of their pre-operative symptoms because of the surgical intervention performed for them.

Five patients suffering from endometriosis have undergone the operation for autograft performed by one of us (Counseller) since 1936. All 5 of

these operations were done by the method of multiple implantation. Four of these 5 patients have obtained good results. The average age of patients of this group at the time of operation was 36 years. In each successful instance at least 2 grafts have remained viable. These 4 women were without symptoms, either of the primary disease or of ovarian insufficiency, as determined by questionnaire on January 1, 1939.

SUMMARY

It is the consensus that the treatment of menopausal symptoms by the administration of the estrogenic hormone produces relief. As a corollary of this, employment of a harmless surgical procedure which provides estrogenic hormone is indicated. For 3 patients for whom treatment was successful, the amount of prolan and estrin excreted in the urine returned to normal values coincident with the enlargement of the nodes. Although some of the autografts may be insufficient to maintain normal values for estrin and prolan, they are sufficient to hold the symptoms of the menopause in abeyance, to prevent atrophy of the genitalia, to maintain certain feminine attributes, and to allow a milder, more natural type of menopause instead of an abrupt, severe, artificial menopause. Multiple implantation has been more successful than the method described by Tuffier in 1910. In selected instances, ovarian autografting has the most to offer the unfortunate group of women who have a disease of the ovaries which cannot be arrested while ovarian tissue remains inside the abdomen. We see no other indication for its performance, because the efficiency of the implanted graft is certainly not that of the ovary which has its natural pedicle.

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SARCOMA OF THE ENDOMETRIAL STROMA

JOHN R. McDONALD, M.D., ALBERT C. BRODERS, M.D., and
VIRGIL S. COUNSELLER, M.D., F.A.C.S.,
Rochester, Minnesota

FEW attempts have been made to differentiate sarcomas which arise from the endometrial stroma from those which are primary in the uterine wall. Sarcomas of the uterine wall frequently, although not always, originate in leiomyomas and assume the histological structure of a leiomyosarcoma, whereas endometrial sarcomas do not. Furthermore, little is known of the course and prognosis of endometrial sarcomas as compared to other neoplasms of the uterus.

Mayer in 1860 described 4 cases of polypoid sarcoma of the endometrium. He noted the similarity between the gross appearance of these lesions and that of certain carcinomas of the fundus of the uterus. In only one of these cases was there an exact pathological diagnosis and that was made by Mayer's brother-in-law, Virchow. The gross and microscopic appearance of endometrial sarcomas was first accurately described by Virchow in 1865. He pointed out that they could be either polypoid or infiltrative in character and that vaginal bleeding was often a prominent feature of the clinical course. He stated that the neoplasm was usually composed of round cells which often underwent myxomatous degeneration. Although metastasis of these sarcomas was rare, in his opinion the prognosis was poor because of the frequency of local recurrence. Virchow also described mixed sarcomas and carcinomas of the body of the uterus. There is little to add to his description of endometrial sarcomas, although it is likely that Virchow did not distinguish clearly between these neoplasms and leiomyosarcomas.

Since that time numerous reports on sarcoma of the uterine body have appeared, written by von Franqué, Offergeld, Moench and Meeker, and others. Williams in 1894 collected 144 cases of sarcomas of the uterine body from the literature and of these the tumors in 44 instances were confined to the mucous membrane.

Although Williams believed that endometrial sarcomas were the commonest type of sarcoma found in the uterus, more recent authors have concluded that the majority of sarcomas of the uterus are of myogenic nature. It appears that the earlier authors were influenced to a great degree by Virchow's writings on this subject. Masson found only 1 tumor of endometrial origin among 50 sarcomas of the uterus. Vogt (1923) reported 28 cases of sarcoma of the body of the uterus, only 8 of which could be traced as arising from leiomyomas. He did not classify the 20 remaining. Frankl described 38 sarcomas of the body of the uterus, in 15 of which there were no leiomyomas. It has been pointed out by Visher, however, that sarcomas may arise from the uterine musculature in the absence of leiomyomas. In a series of 13 sarcomas of the corpus uteri, Wolfe found only 5 which had originated in leiomyomas. Kimbrough in 1934 reported a series of 38 sarcomas among which he had found 17 that did not originate in leiomyomas. Most of the 17 were situated in the mucous membrane of the uterus. Novak and Anderson in 1937 reported 5 endometrial sarcomas occurring among a series of 59 sarcomas of the body of the uterus.

Although endometrial sarcomas have been described as afflicting young women (Ward, 1931), the consensus is that they usually occur in older individuals. Kimbrough found that 75 per cent of sarcomas which did not originate in leiomyomas occurred in women past the menopausal age, whereas only 10 per cent were classified as afflicting women of the premenopausal age.

It is agreed by Williams, Masson, and Novak and Anderson that practically all endometrial sarcomas on gross examination form a polypoid tumor which projects into the uterine cavity, although occasionally they diffusely infiltrate the uterine musculature without forming a polypoid tumor.

Few groups of endometrial sarcomas have been collected which are large enough to provide an indication as to prognosis. Since the report by Evans in 1920, most observers have felt that the number of mitotic figures discernible at histological examination is of definite value in estimating the rapidity of growth of sarcomas of the uterus. Kimbrough found higher counts of mitoses in the histological study of primary sarcomas (those not associated with leiomyomas) than in similar studies on sarcomas occurring in myomas. He felt that the prognosis was three times more favor-

From the Section on Surgical Pathology and the Division of Surgery, The Mayo Clinic.

able for a patient having a myoma undergoing sarcomatous degeneration than it was for a patient having a primary sarcoma.

In addition to cases of sarcoma of the endometrial stroma, a few cases have been reported in which the sarcoma was associated with adenocarcinoma of the body of the uterus (Gusserow, Goldstine).

Another group of neoplasms located in the uterine mucous membrane is the mesodermal mixed tumors. These tumors were first described by Anderson and Erdmannson in 1869 as occurring in the body of the uterus; a similar type of tumor has also been described as developing in the cervix. Excellent reviews on the subject have been published by Perlstein in 1919, Shaw in 1928, and Meikle in 1936. These tumors are almost invariably polypoid in nature and are seldom infiltrating. Practically all those which have been reported have exhibited myxomatous degeneration of the cells. According to Glynn and Bell, cartilage and striated muscle are frequently present; less commonly, bone fat and nerve. Occasionally, according to Nicholson, carcinoma is present in addition to the sarcomatous elements. Most patients, according to Meikle, in whom mixed tumors of the body of the uterus have been found are of the postmenopausal age. A number of theories have arisen as to the probable histogenesis of this type of neoplasm. Wilms suggested that it originated from rests of the wolffian body. Others, including Wolfe, felt that they represented teratomas. On the other hand, Nicholson in 1918 and Rankin and Broders in 1931 suggested that the process represented a dedifferentiation of the stromal cells of the endometrium to primitive mesenchymal cells from which there is differentiation to the various types of mesodermal tissue.

METHOD

A study, from the gross and histological viewpoints, was made of all tumors of the uterus which had been removed at The Mayo Clinic from 1904 to 1939 in which not only a diagnosis of sarcoma had been made but also in which there was any doubt as to the origin of such a lesion from a preexisting leiomyoma. Many of these were leiomyosarcomas, but of this group 20 sarcomas of the uterus were found which were considered to have arisen in the endometrium.

All specimens were studied histologically by means of sections stained with hematoxylin and eosin; where necessary, special stains were employed. After the histological examination had been completed, the clinical records were examined and pertinent details tabulated.

GROSS APPEARANCE

In the series of 20 sarcomas of the endometrial stroma, the uterus was available for study in 15. In 13 of these uteri, the neoplasm presented itself as a polypoid mass projecting into the uterine cavity (Fig. 1). Invasion of the musculature was recognizable to the unassisted eye in 4 of these sarcomas. In all cases except 2, the sarcoma was located in the region of the fundus. The 2 remaining were situated lower down in the uterus immediately superior to the external os. In most of the specimens of sarcoma of the endometrial stroma, the tumor was localized in one portion of the uterus and seldom involved the entire endometrium. Leiomyomas were present in 4 cases, but in all specimens they were histologically benign and in no way appeared to be connected with the malignant neoplastic process. Many of these leiomyomas were small, seldom being larger than 1 centimeter in diameter. An ovary in one case was involved by a fibroma, and several ovaries presented follicular cysts, but otherwise there were no incidental pathological findings. Most of the ovaries were sclerotic, like those of women past the menopausal age.

HISTOLOGICAL APPEARANCE

The neoplastic cells were spindle-shaped on longitudinal section and round on cross section. Frequently, there was ulceration of the surface with resultant infection of the tumor. The more rapidly growing neoplasms exhibited regions of necrosis. In one sarcoma of the endometrium there were numerous foreign body as well as giant tumor cells.

In many of the specimens there were varying degrees of myxomatous degeneration of the neoplasm. This myxomatous substance did not stain reddish with mucicarmine stain, as does the mucus secreted by epithelial cells. This type of degeneration was of value in distinguishing leiomyomas from sarcomas of the endometrial stroma, inasmuch as myxomatous degeneration rarely characterizes leiomyosarcomas.

All the sarcomas in this group were graded numerically according to the method of Broders. One was graded 1, 9 were graded 2, 6 were graded 3, and 4 were graded 4. Mitotic figures were demonstrated in all the sarcomas. There was considerable variation in the number of mitoses in the various tumors. Mitotic figures were more numerous in those neoplasms of high grade malignancy. Pathological mitotic figures were demonstrated in 7 of the 20 sarcomas.

There was a marked tendency in several instances for neoplastic cells to become grouped

around blood vessels. At times, this grouping was sufficiently marked to simulate the appearance of endothelioma or angioblastoma. However, other regions of the tumor could be shown to have the histological appearance of an endometrial sarcoma, and it was occasionally possible to trace the development of tumor cells directly from the cells of the endometrial stroma. It would appear that true endotheliomas are of rare occurrence in the body of the uterus.

Adult collagen fibrils were demonstrated in 2 instances. In both, the collagen fibrils were located between and were unquestionably formed by the neoplastic cells (Fig. 2). Such an appearance is seen in the more differentiated fibrosarcomas and is convincing evidence that sarcomas of the endometrial stroma are fibroblastic in origin.

Invasion of the smooth muscle of the uterus was present histologically in all except 2 cases of that group of sarcomas in which the uterus was available for study. In several instances the process had extended through the entire thickness of the musculature, although serosal involvement could not be demonstrated in any specimen. Neoplastic cells occasionally could be demonstrated in the smaller veins and lymphatic vessels (Fig. 3).

In 6 specimens it was possible to show the transition from normal stromal cells to neoplastic cells (Fig. 4, a and b). This transition was sharply defined histologically. In the tumor, in the vicinity of this transitional tissue, a few non-neoplastic endometrial glands could be found, but they were absent in the other parts of the tumor. That portion of the endometrium which was not involved by the neoplasm did not vary from normal in appearance. The majority of endometria were of the atrophic type occurring in women past the menopausal age.

Fig. 1. Sarcoma of the endometrial stroma (Case 17). The tumor is polypoid and is attached to the fundus of the uterus. A parovarian cyst is present on the left side.

Two of the 20 malignant tumors presented a histological picture similar to those described in the literature as mesodermal mixed tumors. One of these has already been described by Rankin and Broders as a fibromyxochondrosarcoma. This neoplasm was made up of myxomatous connective tissue containing islands of hyaline cartilage

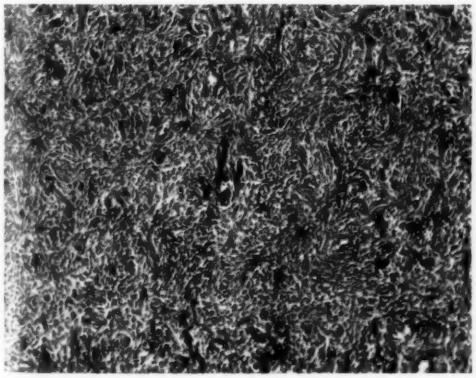

Fig. 2. Sarcoma of the endometrial stroma (Case 14), showing the arrangement of adult collagen fibrils between the neoplastic cells. Hematoxylin and eosin, ×100.

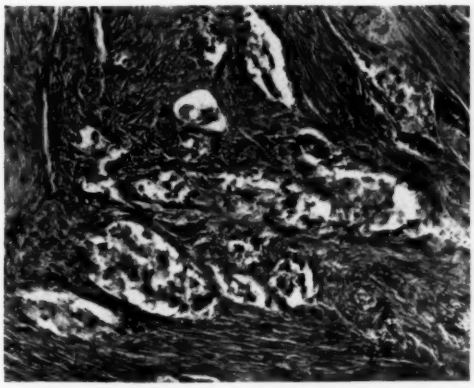

Fig. 3. Sarcoma of the endometrial stroma (Case 6). The lymphatic vessels in musculature of uterus are filled with neoplastic cells. Hematoxylin and eosin, ×117

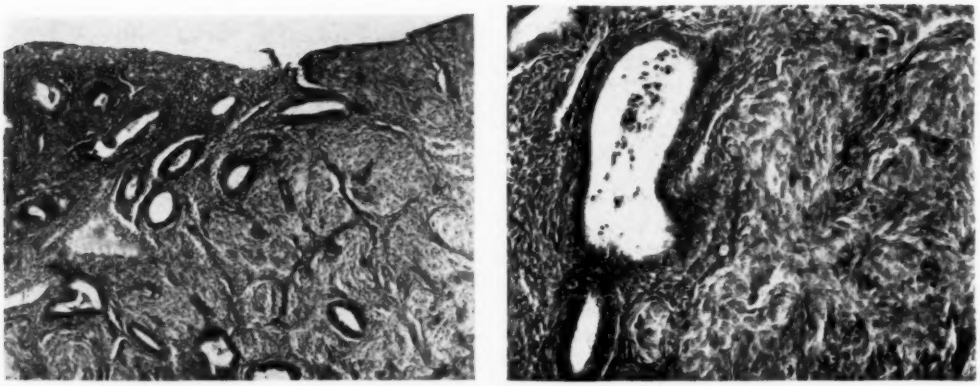

Fig. 4. a, left. Sarcoma of the endometrial stroma (Case 6), showing the transition between normal stroma of the endometrial tissue on the left, and the sarcomatous tissue on the right, hematoxylin and eosin, ×50; b, same specimen under more powerful magnification, showing glands in normal endometrial tissue; hematoxylin and eosin, ×117.

(Fig. 5). Both the fibroblastic and cartilaginous elements of this tumor were malignant, and were graded 2 according to cellular activity. In the other case (unreported), the tumor was a polypoid mass projecting into the uterine cavity. On histological examination it exhibited regions of fibrosarcoma, chondrosarcoma (both undergoing myxomatous degeneration), and adenocarcinoma (Fig. 6). Both the sarcoma and carcinoma were of grade 4 malignancy.

CHRONOLOGY AND SYMPTOMATOLOGY

The average age of the patients concerned in the entire group was 45 years. The youngest patient was 15 months old and the oldest was 71 years old. Nine out of the 20 patients were more than 50 years of age. The 2 patients who had chondrosarcomas of the uterus were 36 and 61 years old. Half of the 20 patients had been delivered of children; the average number of children born to a patient was 2.7. Ten patients were nulliparous.

The commonest symptom was vaginal bleeding or discharge; this symptom was present in 17 cases. The mass of the tumor could be visualized protruding through the cervix into the vagina in 3 cases. Frequency of urination was a symptom in 2 cases. An abdominal tumor could be palpated in 2 cases. The symptoms were of less than 1 year's duration in 18 cases. In 1 case the symp-

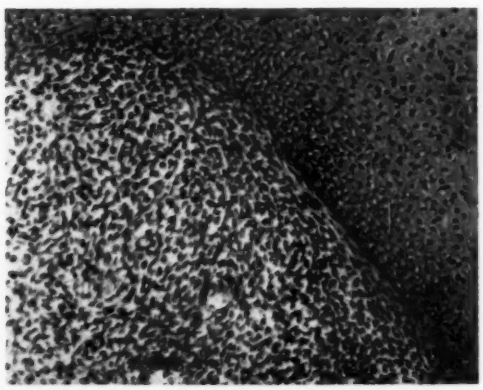

Fig. 5. Fibromyxochondrosarcoma of the endometrial stroma (Case 19), showing the transition from fibroblasts to cartilaginous cells. Hematoxylin and eosin, ×140.

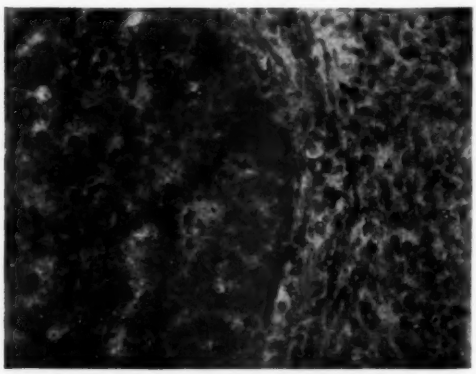

Fig. 6. Mixed sarcoma and carcinoma of endometrial stroma (Case 20). Note contrast between sarcomatous and adenocarcinomatous cells. Hematoxylin and eosin, ×185.

TABLE I.—DIAGNOSIS, TREATMENT, END-RESULTS: SARCOMA OF THE ENDOMETRIAL STROMA, 20 CASES

Case	Pathological diagnosis and grade of tumor	Treatment	End-results	Traced	Not traced	Died after operation
1	2, fibromyxosarcoma	Hysterectomy	Living 6 years	1		
2	1, fibromyxosarcoma	Hysterectomy	Living 6 years	1		
3	4, fibromyxosarcoma	Hysterectomy	Living 3 years	1		
4	2, fibromyxosarcoma	Hysterectomy	Died 6 years later, no recurrence	1		
5	3, fibromyxosarcoma	Hysterectomy	Died	1		
6	2, fibromyxosarcoma	Hysterectomy	Died	1		
7	2, fibromyxosarcoma	Hysterectomy	Died after operation			1
8	3, fibromyxosarcoma	Hysterectomy, roentgen-ray	Died	1		
9	4, fibromyxosarcoma	Hysterectomy (elsewhere), radium, roentgen-ray	Died	1		
10	4, fibromyxosarcoma	Hysterectomy	Died	1		
11	3, fibromyxosarcoma	Hysterectomy (elsewhere), radium	Died	1		
12	3, fibromyxosarcoma	Hysterectomy	Died	1		
13	3, fibromyxosarcoma	Hysterectomy	Living, metastasis to 1st thoracic vertebra	1		
14	2, fibromyxosarcoma	Biopsy, radium, roentgen-ray	Died	1		
15	2, fibromyxosarcoma	Removal of tumor, radium	Died	1		
16	3, fibromyxosarcoma	Removal of tumor, radium	Died after operation			1
17	2, fibromyxosarcoma	Hysterectomy, radium	No record		1	
18	3, fibromyxosarcoma	Hysterectomy	No record		1	
19	2, fibromyxochondrosarcoma	Hysterectomy	No record		1	
20	4, fibrochondrosarcoma and adenocarcinoma	Hysterectomy	Lived 1 year	1		
			Totals	15	3	2

toms were of 2 years' duration, and in another of 3 years' duration.

Hysterectomy was employed as the sole treatment in 13 instances. In 4 others, it was combined with roentgen-ray treatment and radium. In 3 instances, radium was used without hysterectomy after removal of the tumor or a specimen of it for biopsy.

END-RESULTS

Death occurred after operation in 2 instances, a surgical mortality of 10 per cent. One of these deaths (Case 7) was caused by pneumonia following panhysterectomy; the other (Case 16) occurred following the vaginal removal of an ulcerated and infected tumor which protruded through the cervix into the vagina.

Of the 18 remaining patients, 2 (Cases 1 and 2) were living and well at the end of 6 years. One patient (Case 4) died 6 years following hysterectomy for sarcoma of the endometrial stroma, death being caused by a streptococcic sore throat, with no evidence of a recurrence of the malignant neoplasm. One patient (Case 3) was living, with no demonstrable recurrence, 3 years after operation, although chronic cystitis was present. One patient (Case 18) was observed too recently for us to draw any conclusions as to longevity. Nine patients died, death being the result either directly or indirectly of recurrences of the neoplasm, at periods varying from 3 months to 4 years, following operation. Only 3 of these 9 patients lived 1 year or longer. One patient—still living (Case 13)—was afflicted by transverse myelitis in the thoracic region 11 months following total hysterectomy, a condition which biopsy proved to be the result of metastasis from the uterine sarcoma. One of the patients who had mixed mesodermal tumors was not traced, while the other (Case 20) was living 1 year following surgery. Pathological diagnosis, treatment, and end-result for each of these 20 patients are presented in Table I.

The grade of malignancy can be correlated with the end-results only in cases in which the patients

were traced. Of the 18 patients who survived the initial surgical treatment, 15 patients were traced, while 3 were not traced. Only 1 sarcoma was graded 1 according to cellular activity. The patient afflicted by this sarcoma was living 6 years after operation. Of the 5 patients who had sarcomas of grade 2 malignancy, 1 was living 6 years and another 2 years, after operation; 1 died of a recurrence 1 year after operation, 1 died of a recurrence 1½ years after operation, and 1 died of a recurrence 4 years after operation. Five patients had a sarcoma that was graded 3; 4 of these 5 patients died at periods ranging from 3 months to 7 months after operation. One of these 5 patients had a proved metastasis 11 months after the initial treatment, although still alive.

Four patients had a grade 4 sarcoma. One of these 4 patients was living and well 3 years after hysterectomy; 2 died 4 and 6 months, respectively, following the operation. The fourth patient, who had a fibromyxochondrosarcoma and an adenocarcinoma was living and well 1 year after surgical intervention.

COMMENT

Although the gross appearance of the majority of endometrial sarcomas is typical, a polypoid tumor projecting into the cavity of the uterus does not always prove to be an endometrial sarcoma. A small percentage of adenocarcinomas, particularly the more malignant ones, can present a similar gross appearance.

As has already been mentioned, an endometrial sarcoma should be regarded as a fibrogenic sarcoma rather than as a type of sarcoma *sui generis*. Two sarcomas in this group had become so differentiated that collagen fibrils had been formed. Furthermore, the histological appearance of this type of tumor corresponds to the histological appearance of fibrosarcomas situated elsewhere in the body, and the prognosis for both is the same. If this is true, therefore, the cells of the endometrial stroma must be regarded as fibroblasts, although as such they are somewhat modified. An exception is encountered in considering the group of so called "mixed tumors" which invade the body of the uterus. In the two "mixed tumors" encountered in this series, there were regions of chondrosarcoma in addition to regions of fibrosarcoma. In addition, one of these tumors was reported as exhibiting grade 4 adenocarcinoma. It appears that these unusual tumors most likely arise by a process of dedifferentiation of the stromal cells, after which process differentiation takes place, into various types of mesodermal structures, as has been suggested by various authors. In fact, it was possible in examining sections from both "mixed tumors" in this series to trace the fibroblastic cells to the point where they changed to cartilaginous cells. On the basis of such a demonstrated development, these particular neoplasms can be considered to be true endometrial sarcomas. It could be suggested that the presence of carcinomatous elements in one of these neoplasms implies a teratoid origin, as has been suggested by Wolfe. However, Nicholson has reported carcinomatous elements as occurring in these mixed tumors, and Gusserow and Goldstine have reported them as occurring in the ordinary type of endometrial sarcoma. It would seem that the appearance of such elements is an incidental finding.

The symptoms of the patients in this group are very similar to those of patients having adenocarcinoma of the fundus of the uterus. After curettage, it may be impossible to make a diagnosis on the basis of the tissue removed, because the polypoid tumor has a tendency to elude the curette, whereas adenocarcinoma does not.

Although only 9 of the patients in the series were more than 50 years old, in 2 others menopause had been induced by means of radium and roentgen rays, a total of 11 patients who could be considered as being past the menopausal age. This percentage of 55 is considerably lower than that of Kimbrough who found that 75 per cent of sarcomas that did not arise in leiomyomas afflicted patients past the menopausal age.

Because of superficial ulceration of the tumor accompanied by infection, vaginal removal of these tumors may result in a fatal infection. This happened to one of the patients in this series.

One of the striking features of this group was the high mortality resulting from recurrence of the neoplasm. Excluding the 2 patients who died after operation, 66.6 per cent of those traced died or suffered from recurrence; 20 per cent lived 6 years or longer. This high incidence of recurrence is referable not only to the high average grade of malignancy, but also to the tendency of the neoplasm to invade the musculature and small blood and lymphatic vessels.

SUMMARY AND CONCLUSIONS

Twenty cases of sarcoma of the endometrial stroma have been described. Two of these sarcomas belong to the group of so called mixed mesodermal tumors. The majority of these sarcomas produced a polypoid tumor which projected into the uterine cavity. They probably

belong to the general group of fibrosarcomas, since they occasionally differentiate to form collagen fibrils. The commonest symptom was bleeding. There was a mortality of 66.6 per cent as a result of recurrence of the neoplasm among those patients who were traced.

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RHABDOMYOSARCOMA OF THE CORPUS UTERI

R. E. LEE GUNNING, M.D., and CHARLES A. ROSS, M.D., Galesburg, Illinois

RHABDOMYOSARCOMA refers to tumors containing striated muscle cells of embryonic type. Shaw speaks of a group of "mixed tumors" which he has classified according to location as grape-like sarcomas of the cervix uteri, tumors of the corpus uteri of the general type which will be discussed in this paper, and sarcoma of the vagina seen most frequently in young children. He states that striated embryonic muscle cells, cartilage, fat, bone, and sarcoma cells have been found in these tumors. They all contain some type of heterologous tissue.

Of the 3 types mentioned by Shaw those of the corpus uteri are the least common. Including the case reported here, there have been only 10 cases in the literature. Rhabdomyosarcoma is rare in any organ of the body; Cohen could find only one case in 18,077 cases at the Philadelphia General Hospital. The bulk of this tumor was found in the right kidney region and did not originate from the uterus. Lochrane could find only 8 reported cases of rhabdomyosarcoma of the corpus uteri up to 1933. Since that time, Moraes and Rica have reported 1 case.

Many theories have been advanced concerning the pathogenesis of these tumors. That they may be a result of metaplasia from pre-existing smooth muscle either in the myometrium or the blood vessel walls has never been sufficiently proved. Anderson and Edmannson thought that the cross-striped muscle cells had arisen out of the spindle cells of connective tissue in the upper and back part of the cervix and the lowest part of the corpus uteri. Shapiro believes that his case developed embryonic striated muscle cells from embryonic rests displaced in the downward growth of the wolffian duct. Glynn and Blair-Bell have noted the presence of involuntary muscle cells as has Lochrane, but regard them as embryonic cells from which the striated muscle cells originated. They explained this on the basis that plain and striated muscle cells arise from a common mesodermal embryonic type.

Several similar, but not quite typical, cases have been found in the literature. Harding and Hankins report a case of rhabdomyoma of the uterus in a negro girl of 3 years, which seemed to arise from the anterior wall of the uterus below the uterovesical fold. This tumor contained embryonic myoblasts in all stages of development. Reeb and Oberling reported a case of rhabdomyosarcoma and cylindrical epithelioma of the corpus uteri occurring in the same tumor. Their patient was 51 years of age and 4 years past the menopause. She died with vaginal metastases 2 months after a total hysterectomy. These last 2 cases were not included in the accompanying table, because of the atypical location of the first and the unusual pathology of the second. They may, however, very well be classified in the same general group of mixed tumors of the uterus.

Fig. 1. Gross specimen showing uterus open with tumor attached to fundus.

Fig. 2. Photomicrograph showing many cells with well marked cross striations.

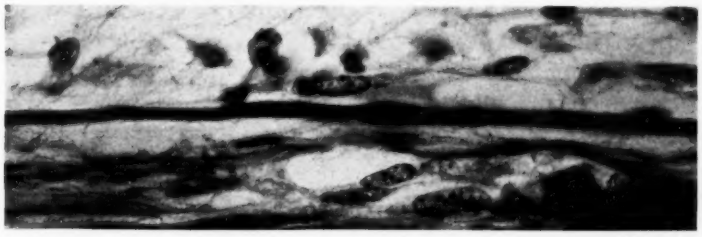

Fig. 3. Photomicrograph showing long, thick fibers with typical cross striations.

CASE REPORT

A white female 58 years of age, married, with 4 living children was admitted to the St. Mary's Hospital January 2, 1939. She gave a history of her menses having ceased 10 years previously and stated that she had been in good health until 2 months before when she began to pass clots which at times had a bad odor. Physical examination revealed a robust Swedish female with normal temperature, pulse, and respirations. The blood pressure was 160/80 and her weight was 171 pounds, which was normal for her. Upon vaginal examination, the uterine fundus could not be made out, because of obesity. The cervical os was filled with necrotic tissue and blood clots. The urine had a specific gravity of 1.022, a trace of sugar and bile, the albumin was two plus, and there were 16 to 25 pus cells per high power field centrifuged. The blood count showed hemoglobin 96 per cent; red blood cells, 5,320,000; white blood cells, 6,700; polymorphonuclears, 60 per cent, eosinophiles, 6 per cent; and lymphocytes, 34 per cent. The blood Kahn test was negative.

From January 3 to January 5, the patient passed necrotic tissue resembling placental remnants which was too degenerated for microscopic examination. During this period, she developed a temperature up to 102.4 degrees that returned to normal when she stopped passing tissue.

On January 14, a supracervical hysterectomy and appendectomy were performed. The tubes and ovaries were normal and there were a few pericholecystic adhesions. The patient made an uneventful recovery. She was discharged February 1 in good condition and has remained to date without evidence of recurrence.

The tissues removed were sent to the St. Francis Hospital in Peoria where they were examined by Dr. M. G. Bohrod to whom we are indebted for the following report:—

The specimen of tissue passed from the cervix was a mass of necrotic, slightly gelatinous material. On section, only occasional spindle shaped and oval cells were seen, but they were too indistinct for any adequate diagnosis.

The uterus was 6 centimeters long and had been amputated above the cervix (Fig. 1). The lumen was filled by a medullary gray, slightly gelatinous mass which had its origin from the posterior wall of the uterus extending laterally part-way up both lateral walls. The surface was lobulated. On section, the tumor was found to be medullary and sharply separated from the muscle of the wall. There was, however, no capsule. Areas of necrosis were present but no hemorrhage. In spite of the sharp gross demarcation, sections showed incomplete separation between tumor and myometrium; groups of tumor cells extended into otherwise normal smooth muscle tissue. In the routine hematoxylin and eosin stains, the tumor cells varied in appearance from place to place and even in the same areas. They were round, spindle shaped or oval, had abundant but poorly demarcated cytoplasm and large vesicular nuclei. Nucleoli were prominent in most of the cells. Many of the nuclei were cigar-shaped and looked very much like the smooth muscle nuclei of the myometrium. Fibrils were found between the cells and extending out from the more spindle shaped cells. It was obvious from the routine stains that the tumor did not resemble any of the well known tumors of the uterus. Very careful study disclosed a very few cells in which faint cross striations could be seen. Stains by Mallory's phosphotungstic acid hematoxylin and Heidenhain's iron hematoxylin, particularly the former, disclosed the true nature of the tumor. The cells showed very well defined cross striations. What was surprising, however, was the large number of cells which showed these findings. In previous reports only

Fig. 4. Photomicrograph showing large protoplasmic cells with faint striations.

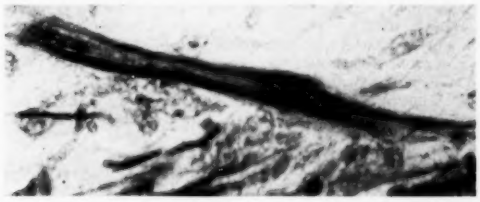

Fig. 5. Photomicrograph showing tubular cell with cross striations.

TABLE I.—RÉSUMÉ OF REPORTED CASES OF RHABDOMYOSARCOMA OF THE CORPUS UTERI

Author	Date reported	Age, years	Past menopause	Presenting symptoms	Recurrence or metastases	Treatment	Result and pathology
Gunning and Ross	1939	58	10 yrs.	Vaginal hemorrhage 2 mos. Passed necrotic tissue from vagina	None to date	Subtotal hysterectomy	Good. Embryonic striated muscle fibers in tumor
Moraes and Rica	1938	56	2 yrs.	Vaginal hemorrhage	None	Curettage, transfusion, total hysterectomy, roentgen therapy	Good. Cellular polymorphism with giant cells in tumor. Embryonic striated muscle fibers in tumor
C. D. Lochrane	1933	56	3 yrs.	Vaginal hemorrhage	None	Curettage, panhysterectomy	Good. Striated muscle fibers in tumor
Shapiro	1931	52	22 yrs.	History of uterine fibroid 5 yrs. Nausea and vomiting. Loss of weight. Abdominal pain 2 mos.	None mentioned	Emergency measures	Died within 24 hrs. after admission. Embryonic striated muscle fibers in tumor. Subserous tumor
Laeven	1906	60	6 mos.	Mild vaginal hemorrhage. Uterus not enlarged but showed evidence of malignancy	To abdomen	Subtotal hysterectomy, total hysterectomy	Died 2½ yrs. after first symptoms appeared. Striated muscle fibers in various forms in tumor
Glynn and Blair-Bell	1914	75	20 yrs.	Sanguineous vaginal discharge 14 mos. Passed tissue from vagina	To intestines and abdomen	Total hysterectomy, enterostomy 2 mos. later	Unknown. Striated muscle fibers in tumor
Glynn and Blair-Bell	1914	62	10 yrs.	Sanguineous vaginal discharge 4 mos. Passed tissue size of orange from vagina	To lungs	Curettage, hysterectomy	Died 6 mos. after hysterectomy. Striated muscle fibers in tumor
von Franque	1893	49	Irregular periods—4 yrs.	Copious vaginal flow with foul odor	None mentioned	Total hysterectomy	Died 1 week after hysterectomy. Autopsy showed chronic nephritis. Cross striped muscle fibers in tumor
Bystronmoff Eckert (quoted by von Franque)	1876		Probably in climacteric	Tumor was attached by a pedicle to base of uterus	None mentioned		Unknown. Completely developed cross striped muscle fibers in tumor
Anderson and Edmannson	1869	50		White tumor mass found in vagina with finger-like excrescences extending from corpus uteri	Recurrence 2 mos. after curettage	Curettage, radical hysterectomy	Died of hemorrhage after hysterectomy. Incomplete elements of cross striped muscle fibers in tumor

small numbers, sometimes only rare cells, were seen with cross striations. In this case, the majority of the cells showed processes with well marked cross striations (Fig. 2). Even the cells with cigar shaped nuclei which resembled smooth muscle cells, showed typical striations. Thick fibers like those seen in skeletal muscle were occasionally encountered. Often they were very long, crossing an entire low-power field of the microscope (Fig. 3). More common were thin fibrils, showing striations. Large protoplasmatic cells with faint striations were also present (Fig. 4). Mitoses were present in small numbers, but there was not a single cell which showed both mitoses and striated fibrils. The cross striations were, for the most part, easier to see than the longitudinal ones.

Of special importance were the presence of tubular cells with cross striations (Fig. 5). These resemble embryonic myoblasts.

The most difficult part of the pathological diagnosis is to think of the possibility of rhabdomyoma. Appropriate stains will bring out the characteristic cross striations. More difficult is the decision as to whether the tumor is malignant. Mitoses, by themselves, merely speak for the rapid growth and not necessarily for malignancy. The imperfect separation of the tumor and the myometrium indicates invasiveness. Of special importance are the tubular myoblasts which indicate the embryonic nature of the tumor. From the morphological point of view, no decision can be made among the various theories for the origin and pathogenesis of rhabdomyosarcoma.

ANALYSIS OF CASES REPORTED ELSEWHERE

From a clinical and pathological viewpoint certain characteristics are common to these cases (Table I). They all occurred in women in the fourth decade or beyond—the oldest patient was 75 years of age and the youngest 49. Most were noted in patients past the menopause; von

Franque's case occurred during the menopause and 1 patient, the case of Glynn and Bell, was 20 years past the climacteric. The early symptoms are usually vaginal hemorrhage and the passage of tissue from the cervix. Recurrences or metastases are mentioned in 4 of the cases and 4 of the patients died as a direct result of the rhabdomyosarcoma. One other patient died soon after a hysterectomy and the autopsy showed a chronic parenchymatous nephritis. The results were good in 3 cases; in 2 cases the results were not reported. Hysterectomy was performed in 7 of the cases, curettage in 4, enterostomy in 1, and roentgentherapy was used in 1. Two had no operations reported. Striated muscle cells were found in all of the cases, but embryonic or degenerative changes were suggested in only half of the cases. They were undoubtedly present in all.

A routine search for cross striated muscle fibers in atypical sarcomas of the uterus may disclose the fact that these tumors are not quite as rare as the reported cases would imply.

SUMMARY

1. Rhabdomyosarcoma of the corpus uteri is a very rare tumor, only 10 cases having been reported to date.

2. A uterine rhabdomyosarcoma occurring in a 58 year old woman 10 years past the menopause is described clinically and pathologically.

3. A summary of the 10 typical cases which have so far been reported is presented and reveals the fact that these tumors occur in women past the menopause, that they are prone to metastasize, and that all contain embryonic forms of striated muscle cells.

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PHLEGMONOUS GASTRITIS

ELLIOTT C. CUTLER, M.D., F.A.C.S., and J. HARTWELL HARRISON, M.D.,
Boston, Massachusetts

IT is the purpose of this paper to describe again the disease known as phlegmonous or suppurative gastritis. The disease was observed by Galen and a diagnosis of cold abscess of the stomach was made by Petrus Forestus in 1597. Though the first pathological description was made in 1617 by Verandaeus (published in 1620 by Romani à Costa), and though the disease presents a classical picture, the physician is unable, even today, to make a clinical diagnosis. A correct pre-operative diagnosis has been made only once in over 300 cases reported in the literature. A consideration of important data from the literature and a presentation of 3 additional cases are to be given here.

Definition. Phlegmonous or suppurative gastritis is a pyogenic infection of the stomach. It begins as a localized cellulitis which may become either a circumscribed abscess or a diffuse phlegmon.

Etiology. The most common organism causing this disease is the streptococcus. Sundberg reported streptococci in the gastric wall of 71 of 95 patients on whom bacteriological studies were made. Guy, Meyer, and Brams recorded a case of streptococcus bronchopneumonia complicated by this condition. Direct contact with infectious material has been assigned as a cause of gastric phlegmon, for example, after tonsillitis, stomatitis, purulent bronchitis, drainage of oral abscesses, and tooth extraction. Gerster pointed out the possible significance of injury of the mucosa by chemicals, poisons of spoiled food, and even external trauma. He found instances of gastric phlegmon associated with ulcer or carcinoma of the stomach in over 50 cases. He observed that phlegmon of the stomach rarely occurs as a part of general sepsis. However, Martland and Eisenberg mention several cases that were observed at autopsy during the epidemic of puerperal sepsis in Prague in 1847. It has occurred also following erysipelas and furunculosis. Lyall described a case of suppurative gastritis caused by penetration of the mucosa by a fish bone.

Sundberg found that there was hypo-acidity of the gastric secretions in all of his cases. Stieda has been quoted as having performed 64 gastric operations on patients with low acid values. Postoperative infections developed in 30 per cent while in 35 patients with high acid values only 2.8 per cent had complicating infections. Exhaustion from hard labor, alcoholism, chronic gastritis, and hypo-acidity of the gastric secretions are considered as predisposing factors to the disease.

Rankin and Miller and Lawrence have described cases of suppurative gastritis associated with cholecystitis and cholelithiasis. Lehnoff, Brooks and Clinton, and others have reported cases of phlegmonous gastritis developing in the presence of carcinoma of the stomach. Bircher cites gastric ulcer as the possible portal of entry for the infecting organism. MacAulay quotes Reeves as having shown that the blood vessels in the submucosa at the common sites for ulcer are longer, smaller, and have fewer anastomoses than elsewhere in the stomach. He says that these vessels are more likely to be occluded by emboli and assumes that they are an important factor in the production of ulcer by hematogenous infections. It is proposed by MacAulay that this mechanism may obtain in the development of suppurative gastritis.

Incidence. Eliason and Murray-Wright found that 83 per cent of cases of suppurative gastritis occurred between the ages of 30 and 60 years. Sundberg found that only 8 per cent of patients were individuals of the well-to-do classes of society; 25 per cent of them had indulged in excessive consumption of alcohol. It has been found that the condition is 3 times more frequent in men than in women (24). Lawrence, in a review of 5,000 autopsies, found only 2 instances of gastric phlegmon.

Pathology. The suppurative process may occur in both a generalized and a localized form; it involves predominantly the submucosa but may extend into the muscularis and even involve the serosa. Perforation into the abdominal cavity usually results in a fatal peritonitis; the contents of the abscess cavity may be emptied into the gastric lumen by spontaneous perforation. In the generalized variety the inflammation extends from the esophagus to the pylorus and involves the entire stomach. As in our Case 1, relatively large collections of pus, 200 to 500 cubic centimeters, may accumulate in the submucosa. In the localized form, of which we are to report 2 cases, either

Surgical Clinic of the Peter Bent Brigham Hospital and the Department of Surgery of the Harvard Medical School.

focal abscesses occur or there may be areas of subacute local inflammation that never progress to frank suppuration. The infection, even in the diffuse form, does not usually extend beyond the cardiac or pyloric orifices. The duodenum was involved also in cases of Eliason and Murray-Wright and Greaves.

The involved portion of the stomach wall is thickened, indurated, edematous, and inflamed. Upon section, seropurulent fluid may be expressed from the tissue. The submucosal space may contain a lake of pus and necrotic débris. The mucosa exhibits a loss of rugæ but is usually intact except for an occasional tiny area of erosion. On palpation the stomach wall feels hard and rubbery.

Microscopic sections show thickening and edema of the submucosa with extensive infiltration by polymorphonuclear leucocytes. Numerous organisms may be demonstrable. Areas of necrosis and perivascular infiltration by leucocytes are frequent. The muscle bundles may be involved by large collections of polymorphonuclear leucocytes. In addition to the acute inflammatory reaction, areas of granulation tissue containing numerous fibroblasts are present. Dr. Wolbach was impressed by the lack of collagen formation by the cells of the granulation tissue in our Case 1. Adjacent lymph nodes showed a marked inflammatory reaction and intense infiltration with polymorphonuclear leucocytes.

Many attempts to reproduce this disease in dogs have been unsuccessful. Fink has injected pure cultures of streptococci into the submucosa of the dog's stomach as well as having fed the organisms by mouth and injected them intravenously without producing suppurative gastritis. However, Doehle is quoted by Vaughan as having produced a cellulitis of the stomach by feeding dogs alcohol and later pure cultures of hemolytic streptococci.

Diagnosis. The only recorded pre-operative diagnosis of phlegmonous gastritis was made by Marshall. The patient was a man, aged 54, who one month after having had drainage of a pneumococcal empyema began to vomit a bright red, jelly-like substance that contained no pus, bile, or fecal material. The temperature was subnormal, pulse rate 104 per minute, and respirations 20 per minute. The abdomen was flat without demonstrable evidence of peristalsis. There was resistance to palpation over both rectus muscles without any notable tenderness. There was an absence of hydrochloric acid in the gastric contents. On the basis of these findings a pre-operative diagnosis of acute inflammation of the stomach was made. Exploratory laparotomy was performed and the stomach was found to be diffusely tense, swollen, and edematous. The swelling extended from the cardia to the pylorus. Drainage of the stomach was not performed and the patient made an uneventful recovery. This is an example of the diagnosis of a seldom recognized condition by the prepared mind.

The following characteristic symptoms and signs of diffuse phlegmonous gastritis have been noted in the writings of Sundberg, Gerster, MacAulay, Eliason and Murray-Wright, and others. There is usually sudden onset of intense epigastric pain which is continuous, non-colicky, and localized. Early and frequent vomiting occurs; pus is rarely present in the vomitus and when this occurs it is a most instructive sign. The vomitus is never feculent in nature. Headache, malaise, and acute thirst are early symptoms. Hiccough is not uncommon. Prostration is variable and seldom so extreme as in acute hemorrhagic pancreatitis. There is usually a high temperature of 104 to 106 degrees, but occasionally it has been found to be subnormal. The tongue is dry and coated. There may be a striking prominence of the upper abdomen and retraction of the lower abdomen. Epigastric tenderness remains localized in the upper abdomen unless general peritonitis develops. The patient may get relief from pain upon sitting up. Partial paralysis of the stomach is manifested by continuous vomiting and may be demonstrated by roentgenographic examinations. Upon examination of the stomach contents an absence of hydrochloric acid is usually discovered. There is a leucocytosis of 15,000 to 30,000 leucocytes per cubic millimeter of blood, chiefly of the polymorphonuclear variety.

The conditions to be considered in the differential diagnosis are a basal pneumonia, acute pancreatitis, perforation of a gastric or duodenal ulcer, acute cholecystitis, and calculus in the common hepatic duct. In most cases the surgeon has made a diagnosis of an acute upper abdominal condition necessitating exploration.

The chronic form of phlegmonous gastritis is a circumscribed abscess. It causes symptoms of anorexia, indigestion, and pain in the epigastrium which is made worse by eating. There may be obstructive symptoms and the clinical diagnosis of obstructing ulcer or carcinoma has been frequently made, both before and during operation.

Gerster presumed that there are mild attacks of suppurative gastritis that recover spontaneously without being recognized. Lawrence suggested that the so called postoperative dilatation of the stomach may be a form of gastritis. Death has occurred in a few hours in fulminant cases. There

Fig. 1. Roentgenogram of the stomach, Case 1, 1 hour after a single swallow of barium shows complete retention of the opaque material, loss of normal gastric rugæ, and no evidence of peristalsis.

have been acute attacks lasting 2 to 3 weeks with a fatal outcome usually but occasionally undergoing spontaneous recovery after a protracted convalescence.

Olsson has described the roentgenological picture of phlegmonous gastritis as being characterized by loss of mucosal folds, presence of the mucous lining over the infiltrated area, often a complete gastric retention of ingested barium, and lack of peristalsis. In one of his patients a diverticulum-like deformity of the stomach was demonstrated by fluoroscopy. He warns that ulceration may be overlooked owing to alterations in the surrounding tissues.

TREATMENT

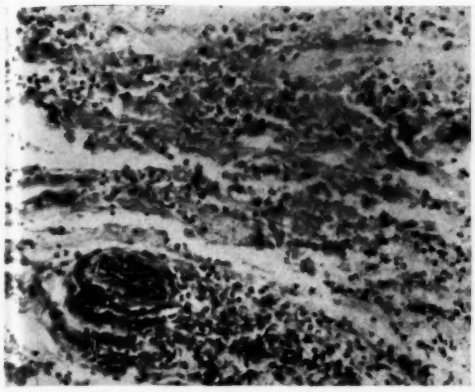
The mortality from phlegmonous gastritis has varied in different series of cases in the literature from 84 to 95 per cent. Eliason and Murray-Wright reported 5 survivals out of 31 patients. Two of the survivals were patients having localized phlegmon. Gastric resection was performed in one of these and gastrotomy in the other. The other 3 patients had diffuse phlegmonous gastritis; simple laparotomy was followed by spontaneous recovery in 2 of these and gastrotomy was performed in the other. Staplemohr, Novak, Zoepffel and Guibal have each performed gastric resection for localized abscess of the stomach with subsequent recovery. The diagnosis was either carcinoma or obstructing ulcer with perigastritis in all at the time of resection. Bovee performed an incision and drainage of a phlegmon of the stomach which resulted in recovery. The cures obtained by drainage and gastro-enterostomy have been considered by most authors as spontaneous recoveries. Gastric resection has been favored as the operation of choice for chronic circumscribed gastric phlegmon.

Acute phlegmonous gastritis may be a rapidly fatal disease, the patient dying within 48 to 72 hours after the onset of the illness. For this type of case only general supportive measures are indicated. However, if the patient survives the initial period of the disease and the condition improves as a result of conservative measures, exploration may be indicated on account of obstructive symptoms or persistence of infection. The use of the gastric tube and parenteral administration of fluid, salt, and dextrose are invaluable therapeutic agents. Operative drainage of the infected focus may be performed only where marsupialization of the gastric wall, with adequate protection of the peritoneal cavity, is possible. Any operative procedure undertaken for such a condition is hazardous and the simpler the procedure the better. Gastric resection is contra-indicated. Spontaneous recoveries have occurred.

For chronic suppurative gastritis the initial problem is usually relief of alkalosis and pyloric obstruction. It is generally considered that patients recovering following operation did so in spite of rather than because of operation. This may be true so far as the infection itself is concerned, but the successful relief of pyloric obstruction is of undeniable benefit.

CASE 1. P.B.B.H. Surg. No. 57809. A student nurse, aged 21, developed an aching pain in the middle of the back and shortly thereafter became nauseated. She vomited about an ounce of orange-colored fluid. During the afternoon she perspired freely, developed a headache, and had 4 watery bowel movements. Twenty-four hours later she had a shaking chill and her temperature was found to be 103 degrees F. Headache persisted and again the next afternoon a chill occurred which lasted for 3 hours. She felt a sensation in the epigastrium of a lump moving up and down beneath the xiphoid. She was admitted to the medical service.

At this time the patient was a well developed, fairly well nourished young woman exhibiting a marked malar flush. The temperature was 104 degrees F., pulse rate 110 per minute, and respiratory rate 20 per minute. The tonsils were absent, but there was injection of the vessels over the anterior pillars and the pharynx was quite red. There were several small, discrete, tender lymph nodes in the anterior



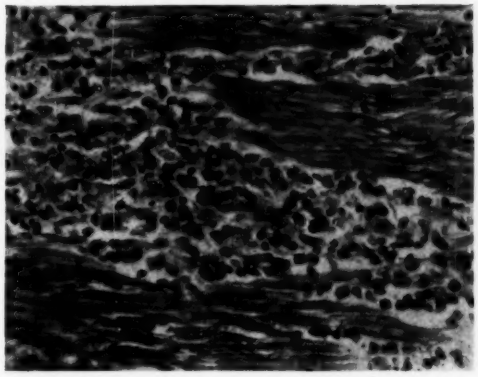


Fig. 2. a, left. Photomicrograph of section which shows extensive leucocytic infiltration and necrosis of muscle and submucosa. ×200. b, Photomicrograph of section which shows no necrosis but the presence of a diffuse infiltration of polymorphonuclear leucocytes between the bundles of muscle. ×300.

cervical chain on the left. The abdomen was symmetrical in contour and not distended; no mass, spasm, tenderness, hernia, or fluid demonstrable by abdominal examination.

The urine was hazy yellow, alkaline in reaction, and had a specific gravity of 1.018; it contained the slightest possible trace of albumin, 2 to 3 white blood cells, many hyaline and granular casts. The hemoglobin measured 95 per cent, the red blood cell count was 4,800,000, and the leucocyte count was 14,800 with 87 per cent polymorphonuclear leucocytes. Repeated blood cultures were negative. A hemolytic streptococcus, among other organisms, was cultured from the throat.

During the first and second days the temperature varied from normal to 102 degrees. On the third day there was a recurrence of malaise, anorexia, nausea, and vomiting. Diffuse abdominal tenderness without muscle spasm gradually developed; this was most marked in the lower abdomen at first but later shifted to a localized band of tenderness extending from the left hypochondrium across the epigastrium to the right hypochondrium. The epigastrium became full but no definite mass was palpable. On the sixth day the temperature went to 106 degrees following a chill. The blood culture was again negative. The patient complained of a constant aching sensation in the epigastrium but the abdomen remained soft with the same distribution of tenderness. Pelvic examination at this time located only diffuse tenderness in both vaults and the presence of a creamy white vaginal discharge without pus cells but loaded with many gram positive cocci. She was placed in high Fowler's position and felt more comfortable. Vomiting persisted and the fluid intake was maintained by parenteral administration. The vomitus consistently was a green watery fluid containing no free hydrochloric acid and from 10 to 50 degrees of total combined acids.

Fluoroscopic examination of the chest showed the diaphragm to move equally and well on the 2 sides. There was no evidence of air beneath the diaphragm. Fluoroscopic examination of the abdomen 20 and 60 minutes after a single swallow of barium showed the barium to be completely retained in the stomach (Fig. 1).

From the ninth to the twelfth hospital day the temperature persisted at a level of 103 to 104 degrees. The white blood cell count fell during this time from 28,000 to 15,000 per cubic millimeter. The upper abdominal tenderness became greater but still there was no rigidity of the muscles. Rebound tenderness became more striking and the pain was consistently referred to the left hypochondrium. There were ever increasing signs of peritoneal irritation and of a localized inflammatory process in the upper abdomen. Necessity for exploratory laparotomy became evident. Pre-operative diagnosis, acute pancreatitis.

A midline epigastric incision was made; the stomach was found to be extremely reddened, thickened, and boggy to palpation. The liver and omentum were adherent to it. The former was freed and the lesser curvature investigated in search of a perforated ulcer, which was not present. The stomach, which was lying quite low in the abdomen, was lifted up and examination of the underlying intestines showed no evidence of a general peritonitis. A hypodermic needle was inserted into the stomach wall and a creamy white, non-odorous pus was aspirated. An incision was made through the muscularis, which was about 1 centimeter thick, entering into a diffuse plane of purulent, viscid fluid. In this lake of pus, which was seen to lie between the muscularis and the mucosa, was a tough slough which was the remains of the submucosa. Material was obtained for microscopic study and culture. Thorough irrigation and aspiration of the infected submucous plane was performed after careful walling off for protection of the general peritoneal cavity. The suppurative process was not localized but seemed to surround the entire stomach from cardia to pylorus. The duodenum was normal in appearance and consistency, as were the gall bladder and pancreas.

Decision as to how to treat this unusual condition was quite difficult. That drainage of the suppurative process was necessary was obvious, but this would have to be done in such a manner as to protect the uninvolved peritoneal cavity. The only conceivable means of accomplishing this was to exteriorize the anterior wall of the stomach at the site of drainage. This was done by stitching the peritoneum to the stomach in the lowermost portion of the wound about the open infected sinus tract. The wound above this was closed with a continuous suture of silk and interrupted silk. The skin and subcutaneous tissues were left open. The gastric mucosa was not opened at any point during the operation. The patient withstood the procedure well considering her debilitated condition. A transfusion of 600

Fig. 3. The healed abdominal wound in Case 1, 4 months after operation. The gastric fistula closed spontaneously 10 weeks after operation.

cubic centimeters of citrated blood was given and this was followed by the administration of 3,600 cubic centimeters of parenteral fluids in the ensuing 12 hours. Postoperative diagnosis, acute suppurative phlegmonous gastritis.

The next day her temperature was 105.8 degrees; a pure growth of hemolytic streptococcus was obtained from the cultures of the pus in the gastric submucosa. The administration of sulfanilamide subcutaneously was immediately started; 5 grams were given by hypodermoclysis on the first postoperative day and 8 grams on the second day. During the next 8 days a maintenance dose of 4 grams daily was administered via the same method. Blood transfusion was repeated on the fourth day. On the fourth postoperative day a spontaneous perforation of the gastric mucosa occurred and the stomach contents began to drain into the wound. The wound was kept dry by constant suction with a perforated rubber catheter.

During the first 3 days after operation the temperature gradually fell from 106 to 101 degrees F. Thereafter it assumed an average elevation of 102 degrees for a week. The sulfanilamide content of the blood was found to be 12 milligrams per cent. It was discontinued after 10 days' administration as the patient was constantly quite cyanotic. The leucocytic count varied from 22,000 to 30,000 during this period. Twenty days after operation her temperature was 98.6 degrees and showed no further elevation during the remaining 32 days in the hospital. The drainage from the fistula had been at times as much as 2,600 cubic centimeters in 24 hours. It usually contained no free hydrochloric acid and a very low total acid. On 2 occasions it was found to contain only 5 units of free hydrochloric acid. The blood vitamin C level was found to be extremely low, 0.05 milligram per cent on the sixth day, and daily administration of vitamin C intravenously was instituted until it was possible to begin a high caloric and high vitamin diet. The patient was discharged from the hospital 52 days after operation, quite well except for a very small sinus tract that needed change of dressing only once daily.

Pathological report—microscopic examination: The most interesting sections were (Fig. 2) those from the muscularis and from portions of the serosa of the stomach. Here there were extensive areas of complete degeneration and loss of structural detail. Such areas contained faintly basophilic necrotic material, large numbers of polymorphonuclear leucocytes, and numerous cocci in short chains. One section of the muscular coat in addition to this acute inflammatory reaction showed several areas of granulation tissue in which there were numerous proliferating fibroblasts. Occasionally there was a faint zone of collagen about single or small groups of fibroblasts. Dr. Wolbach, in reviewing these sections, was impressed by the lack of collagen formation by the cells of the granulation tissue. Such a striking lack, in his opinion, was probably indicative of vitamin C deficiency. Consequently, he advised that the patient receive vitamin C in some form as part of her therapy. One large lymph node section showed a marked inflammatory reaction and intense infiltration with polymorphonuclear leucocytes.

Diagnosis: Acute phlegmonous gastritis due to hemolytic streptococcus; vitamin C deficiency.

The patient was readmitted to the hospital for examination 4½ months after the beginning of her illness. The small gastric fistula had gradually closed during the first 6 weeks at home (Fig. 3). Her appetite returned and there was a 30 pound gain in weight associated with a return to normal strength. Gastric analysis at this time showed no free acid in the fasting contents or after an alcohol test meal, but after histamine 60 units of free acid was present in the first specimen and 110 units in the second specimen. The red cell count of the blood was 5,210,000 and the hemoglobin measured 90 per cent. The blood vitamin C level was measured at 0.29 milligram per cent as contrasted to 0.05 milligram per cent 4 months previously, a few days after operation.

The report of a roentgenographic gastro-intestinal series is as follows: The esophagus appeared normal. The stomach was median in position, smooth in outline with good peristalsis and normal rugæ. There was a constant notching on the lesser curvature at the first portion of the antrum (Fig. 4), otherwise findings normal. The normal filling and emptying, the good peristalsis, and regaining of normal rugæ were roentgenographic evidences of complete recovery.

Ten months after her illness the patient continues to be quite well and has resumed her duties as a student nurse. Gastric analysis now shows a free hydrochloric acid content of 20 to 25 units in the fasting contents of the stomach and the blood vitamin C level is normal. She is entirely free of any abnormal gastric symptoms. Urinalysis is negative.

Case 2. P.B.B.H. Surg. No. 59159. A white man, aged 57 years, entered the hospital because of abdominal pain and vomiting of 6 days' duration. The patient had suffered with indigestion for 12 years. Eighteen months before admission he was examined in another hospital and treatment administered for a duodenal ulcer with obstruction. At that time the gastric contents showed a free acid of 51 degrees and a total acid of 64 degrees. He was quite improved with diet and alkaline therapy. Fourteen months later he was treated on the surgical service of this hospital for duodenal ulcer with obstruction and alkalosis. Gastric retention of 500 cubic centimeters gradually diminished to no retention after 2 weeks and the alkalosis cleared up at the same time. He was discharged after 2 weeks of treatment. Four months later he was admitted to the medical service with the complaints mentioned. Again he was found to be in a state of alkalosis from persistent vomiting. Aspiration of the stomach contents yielded as much as 1,000 cubic centimeters of retained fluid at times. The

arbon dioxide combining power of the blood was 90 olumes per cent and blood urea nitrogen measured 59 illigrams per cent. After 1 week the patient was trans- rred to the surgical service.

At operation a hard, rubbery mass, which practically cluded the duodenum, was found 1 inch below the ylorus. The gall bladder and omentum were adherent to his area and it was felt unwise to separate the adhesions. The stomach was large and on its anterior surface, 4 inches bove the pylorus near the greater curvature, there was an inflamed, indurated area. The gastrocolic omentum near his region was edematous. Incision was made into the inflamed gastric wall and a biopsy made; closure of the stomach wall was made with interrupted silk sutures. A posterior gastro-enterostomy was then made and the abdomen closed without drainage. The postoperative course was uneventful and patient was discharged 2 weeks later.

Pathological report—microscopic examination: The tissue removed from the wall of the stomach consisted of serosa and a portion of the muscular coat. There was no exudate on the surface. The serosa was edematous and was infiltrated with inflammatory cells which, for the most part, were eosinophils. Similar groups of cells were seen to extend between the bundles of muscle and to lie about the vessels. Similar cells were seen in the vessel walls in some places. No micro-organisms were demonstrated. The specimen represented a subacute inflammatory reaction in the muscular and submucosal coats of the stomach. A similar reaction might be found about the base of an ulcer or it might represent a more widespread reaction of gastritis. A section of lymph node showed no evidence of inflammation or tumor.

Diagnosis: Acute and subacute inflammation of the muscle and serosa of the stomach.

Four months after operation the patient is entirely well. He has gained weight and is working regularly. A gastro-intestinal roentgenographic series at this time shows that the posterior gastro-enterostomy is functioning well. There is no crater or tenderness present but the gastric rugæ appear definitely thickened and tortuous.

This case represents a mild form of the type of localized gastritis originally mentioned by Verandaeus. It also serves to remind one of Cruvielhier's hypothesis of the interrelationship of gastritis and ulcer.

Case 3. P.B.B.H. Surg. No. 3684. A salesman, aged 34 years, entered the hospital complaining of "stomach trouble." For 6 weeks there was loss of appetite and for 4 weeks postprandial epigastric pain and vomiting. Soda did not relieve the pain and it was aggravated by all kinds of food. Pain and vomiting became progressively worse and the presence of coffee-ground-like material was noticed in the vomitus.

Upon physical examination the patient was found to be well developed and well nourished. In the epigastrium there was very slight spasm of the rectus muscles and some tenderness on moderate pressure. A positive guaiac test was found upon examination of the stool. Gastric analysis showed 52 degrees of free hydrochloric acid and a total acidity of 85 degrees. The gastric contents consisted of coffee-ground-like material. The leucocyte count of the blood was 14,800 per cubic millimeter; the hemoglobin measured 120 per cent, and the erythrocyte count was 5 752,000 per cubic millimeter. Four hours after administration of a bismuth meal there was a very large residue in the stomach visible by fluoroscopy. The stomach was low in position and appeared atonic. There was an irregularity

Fig. 4. Roentgenogram of the stomach, Case 1, during a gastro-intestinal series 4 months after operation shows a constant notching on the lesser curvature in the first portion of the antrum. Emptying of the stomach was normal at this time.

in the region of the pylorus suggestive of an ulcer in this region. The pre-operative diagnosis was that of ulcer on the lesser curvature of the stomach.

Operation was performed by Dr. John Homans. The gall bladder was adherent to the base of the mesocolon. In the region of the pylorus the sphincter seemed unusually thick and blended into an area of induration which extended medially along the greater curvature for ¾ of an inch. At this region the stomach wall was thickened and felt like the induration of a carbuncle. The stomach was opened and the wall along this portion of the greater curvature close to the pylorus was found to be about 1 centimeter thick. The cut tissue had a grayish, granular appearance. A biopsy of the tissue was made and the pathologist reported a diagnosis of acute suppurative gastritis. In spite of the condition of the stomach wall a Finney pyloroplasty was performed. The operation was quite difficult owing to the thickness of the gastric wall. At completion of the plastic procedure there was a pyloric stoma which would admit 2 fingers.

Eighteen days later the patient was discharged in excellent condition. Roentgenographic examination of the stomach at that time after a bismuth meal showed only a small residue. The peristaltic waves were active. Six months later the patient had gained 30 pounds and had been at work 4 months without symptoms. Eight years later a roentgenographic gastro-intestinal examination showed a residue of 10 per cent of ingested barium at 6 hours. The outline of the stomach was smooth and the pylorus was wide. The second portion of the duodenum showed a sharp kink but no dilatation to indicate obstruction. The impression was that the pyloroplasty was functioning well.

Histological report: The mucus membrane of the stomach was infiltrated with many polymorphonuclear leucocytes and round cells. The capillaries were dilated and there was some extravasation of blood. The mucous membrane in places was ulcerated.

Diagnosis: Acute suppurative gastritis.

SUMMARY AND CONCLUSIONS

One of our patients, Case 1, had severe, acute, diffuse phlegmonous gastritis owing to infection by a hemolytic streptococcus. Marsupialization of the stomach and drainage of the infection, followed by administration of sulfanilamide, resulted in cure. We believe that adequate drainage of the suppurative process played the major rôle in the ultimate recovery of this patient but it is impossible to evaluate the effect of sulfanilamide and vitamin C. The finding of little collagen formation in the granulation tissue suggested to the pathologist the existence of a vitamin C deficiency which was corroborated by blood determinations. It is apparent that this deficiency developed during the acute illness; however, one cannot be certain of this. In any event, there were specific indications for each of the therapeutic measures instituted and a fortunate recovery from an illness that ordinarily has an 80 to 90 per cent mortality was obtained.

Our 2 other patients had localized areas of suppurative gastritis. In Case 2 there was a pyloric stenosis due to an obstructing duodenal ulcer; a biopsy specimen of a distant area of localized gastritis was obtained and a gastro-enterostomy was performed for relief of the obstruction. There was no visible or palpable relation between the ulcer and the suppurative process. In Case 3 the patient had chronic pyloric obstruction which was caused by a localized gastric phlegmon. Pyloroplasty resulted in relief of the obstruction. As the patient recovered and was well 8 years later, it must be assumed that this was a low grade inflammatory process that subsided spontaneously after relief of pyloric stenosis. An ulcer of the stomach or duodenum was not demonstrable then or later.

It is important for the clinician to be cognizant of these two forms of suppurative gastritis in order that the diagnosis may be established more often and, accordingly, more knowledge obtained of the pathogenesis of a disease which, though apparently rare, may at the same time be closely related to a more common disease, peptic ulcer.

This small report again emphasizes the dependence of the surgeon on the pathologist, and we acknowledge our deep gratitude to Dr. S. B. Wolbach and Dr. Darrell Ayer. Their notation of a vitamin C deficiency in Case 1, from a study of the histological preparation, may have been the determining factor in the recovery of this patient.

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OBSERVATIONS ON ACUTE APPENDICITIS

A Series of 635 Cases

IRVING BUSCH, M.D., F.A.C.S., and A. H. SPIVACK, M.D.,
New York, New York

NUMEROUS papers on appendicitis have been appearing in the recent literature. The value of these papers lies in the fact that the mortality of this disease is still out of keeping with the improvement in diagnosis and in operative technique. It is in the hope that we shall be able to add further evidence as to some of the factors causing this disparity that we offer this paper.

This analysis of appendicitis is based on 635 consecutive cases in which patients were operated upon at the Beth Israel Hospital. Both private and ward cases are included and the operations were performed during the period between January 1, 1931, and July 1, 1936. The cases were in no way selected; they include every case in which operation was performed during the period mentioned and in which the microscopic pathological report was acute appendicitis. Neither cases of chronic appendicitis nor those in which the appendix was removed incidentally during a laparotomy for some other disease have been included. Practically every member of the surgical staff of the hospital is represented in the series and in addition some twenty house officers performed many of the operations under the supervision of a member of the attending surgical staff.

The cases were divided into four main categories according to their macroscopic pathology; namely, acute appendicitis, acute appendicitis with local peritonitis, gangrenous appendicitis, and appendiceal abscess. The group of gangrenous appendicitis cases was further subdivided into perforated and non-perforated cases.

To make easier a comparison of this report with others in the literature, we should like to define the first two groups; the latter two groups are self-explanatory. The classification of acute appendicitis we limited to those cases in which there was no macroscopic evidence of peritoneal involvement of the appendix other than a roughening of its serosa; the group of cases of acute appendicitis with local peritonitis to those in which there was thick fibrinous exudate covering the appendix or the surrounding viscera, or fluid in the peritoneal cavity.

A tabulation of our series is shown in Table I.

TABLE I.—CLASSIFICATION OF CASES

	Cases
I. Acute appendicitis	191
II. Acute appendicitis with local peritonitis	200
III. Gangrenous appendicitis	
A. Non-perforated	101
B. Perforated	52
IV. Appendiceal abscess	91
Total	635

HISTORY

Some factors in the history were studied in order to evaluate their importance. In 194 patients (30.7 per cent of the total series), there was a history of one or more previous attacks. From these figures it can be seen that the incidence of acute appendicitis is much higher than would be indicated by vital statistics, inasmuch as many of them do not come to operation until they have had one or more previous attacks. In view of the high incidence of previous attacks in our series, it offers a diagnostic aid.

Chronic constipation as a predisposing factor is relatively unimportant, occurring in only 106 cases (16.7 per cent). Dietary indiscretion played little or no part in this series as it was present in less than 10 patients.

Nausea and vomiting were very frequent symptoms in the immediate history, nausea occurring in 458 cases (72.8 per cent) and vomiting in 378 cases (60.1 per cent). Pain was an invariable symptom in our series, the location varying, but most often was confined to the right lower quadrant of the abdomen during the course of the disease.

Chills were present in 41 cases of this series and it was noted that although these cases were distributed more or less equally throughout the various groups here tabulated, the mortality rate in those patients who had chills in the history was 7.3 per cent in contradistinction to the average mortality for the whole series of 2.2 per cent. The chills as a rule occurred at the onset of the

From the Surgical Service of Beth Israel Hospital.

illness. A more advanced pathology was found in these cases, for 25 of the 41 cases with chills were in groups III and IV. Chills in the history, therefore, warrant a more guarded prognosis.

Diarrhea and frequency of urination were found to be relatively infrequent, the former occurring in 12 patients and the latter in only 10.

SIGNS AND LABORATORY DATA

Abdominal tenderness was a constant sign and preponderantly situated in the right lower half of the abdomen. The localization of the point of tenderness was, however, no indication of the exact position of the appendix.

A study of the pulse rate demonstrated a definite relationship to the severity of the pathological process, a pulse rate over 120 being present in a much larger proportion of the cases with more advanced pathology.

In cases of acute appendicitis, only 6 per cent had a pulse rate above 120; in those with acute appendicitis with local peritonitis the pulse rate was above 120 in 10 per cent; whereas in cases of gangrene of the appendix without perforation, 16 per cent of the cases had a pulse rate above 120. Abscess cases showed a pulse rate above 120 in 21 per cent, while gangrene with perforation had the greatest percentage, namely 30 per cent.

Blood counts were done in 474 patients and were found to be a very reliable indication of the severity of the pathological process. Only 46 cases of the 474 had a white blood count below 10,000 cells per cubic millimeter. A blood count over 15,000 was found in 50 per cent of the cases of acute appendicitis; in 60 per cent of those with local peritonitis; in 72 per cent of those with gangrene whether perforated or not; and in 53 per cent of the cases of appendiceal abscess. In view of the constancy of the elevation of the white blood count in the more severe cases of acute appendicitis, we feel that even if the diagnosis is apparently obvious, a blood count should be done to aid in diagnosis and prognosis.

FACTORS IN INCIDENCE

The age distribution of our series was similar to that reported in the literature. Our oldest patient was 84 years, and our youngest 18 months. The largest number of cases occurred in early adult life and during adolescence; 74.2 per cent of our cases were less than 30 years of age.

The distribution as far as sex was concerned was 385 males and 250 females in the approximate ratio of 3 males to 2 females.

An interesting finding was the seasonal incidence of acute appendicitis. During the 6 month period from March to September, twice as many cases of acute appendicitis occurred as during the other 6 months. Speculation on the above finding might lead one to suspect that there may be some relationship between the occurrence of acute appendicitis and the increased number of intestinal disorders during these months. From such a brief study, it is impossible to arrive at a definite conclusion.

FACTORS IN PATHOLOGY

Our cases were studied from the standpoint of the relationship between the pathological process found at operation and the duration of the preceding symptoms. In general, it may be said that with a longer history the pathological findings were more advanced. Where the history was less than 12 hours, only 9 per cent of the cases were in groups III and IV. A history of 12 to 24 hours showed 28 per cent of the cases in these two groups, and 46 per cent of the cases with a 24 to 36 hour history fell into these groups. Further, a 36 to 48 hour history showed 50 per cent, and a 48 to 72 hour history 70 per cent of all cases belonged to groups III and IV. A history of 72 to 96 hours presented 70 per cent of the cases in these groups, and finally a history of more than 96 hours placed 82 per cent of all the cases into the two groups mentioned.

A short history, however, does not preclude the presence of an advanced pathological process as evidenced in 16 cases of gangrenous appendicitis with perforation in which the history was of less than 24 hours' duration.

Catharsis as a factor in increasing the mortality rate in acute appendicitis has been repeatedly stressed. In an attempt to evaluate the influence of cathartics in this disease, we studied the relationship between catharsis and the type of pathology found at operation.

Since all the deaths in our series occurred in cases of gangrene of the appendix (group III) and in the appendiceal abscess cases (group IV), a comparison was made between the percentage of cases falling into these two groups on the basis of taking cathartics. Information on this point was available in 615 cases. In 420 cases in which no cathartics were taken, 31.5 per cent of the cases belonged to groups III and IV; in 195 cases in which cathartics were taken, 49.4 per cent belonged to groups III and IV. In general, in this series, a definite swing to a more serious type of pathology was noted with the taking of cathartics. Appendiceal abscess, for instance, occurred twice as often in our series in those who had taken cathartics as against those who had not.

FACTORS IN MORTALITY

There were some outstanding factors that were noted in studying the mortalities in our series. Foremost was diabetes. Although there were only 10 patients with accompanying diabetes, it is significant that 3 of the deaths were in this group, representing a mortality of 30 per cent. These patients were in an older age group than the average for the whole series, but when compared to a similar age group without diabetes, it was found that the mortality was 7½ times as great. The pathological condition found at operation in all cases with one exception was very advanced. In view of these facts, cases of acute appendicitis accompanied by diabetes offer a poor prognosis and therefore operation should be carried out without delay.

In the series were 17 patients who gave a history of cardiac decompensation at some time in the past. There was one death in the group, but this patient also had diabetes. This observation confirms the general impression that heart disease *per se* is no contra-indication to urgent surgery in acute appendicitis. Compensated cardiac disease, in our experience, does not alter the prognosis in any way.

We feel that the duration of the disease before operation and the taking of cathartics represent the two major factors in mortality. A study of the 15 deaths in this series from this standpoint bears out this contention.

The average duration of the disease before operation in the 15 mortalities was 5.4 days. Twelve of these 15 cases had a history of symptoms varying from 3 to 14 days.

A history concerning the taking of cathartics was not obtained from 2 patients, but of the 13 others, 8 had taken cathartics. This confirms the impression gained from our series and substantiates the extreme danger of catharsis in acute appendicitis.

TECHNICAL FACTORS IN TREATMENT

In view of the tendency of surgeons to avoid drainage in cases of acute appendicitis, we studied our series with this in mind.

Drainage was used in only 10 of 191 cases of acute appendicitis; in 33 of 200 cases of acute appendicitis with local peritonitis; in 45 of 103 cases of gangrenous appendicitis without perforation; in 48 of 52 cases of gangrene with perforation; and in 84 of 91 cases with appendiceal abscesses.

Some explanation as to the omission of drainage in the cases of gangrenous appendicitis with perforation and abscess is necessary. The 4 cases of perforation of the appendix in which no drainage was used were all cases in which the perforation was occluded by omentum or by adjacent intestine, and in the opinion of the surgeon there was no reason for drainage. The 7 cases of abscess which were not drained were all mesenteric abscesses removed *in toto* together with the appendix without opening into the abscess and were therefore judged to be relatively clean cases.

Drainage was also studied as to its effect on the length of hospitalization. In 180 cases of acute appendicitis, with no drainage, the average stay was 12.2 days; in 10 cases of similar pathology in which drainage was used, the average stay was 14.4 days. In 167 cases of acute appendicitis with local peritonitis in which drainage was not used, the average stay was 13.8 days, whereas 33 patients with similar pathology in whom drainage was used, remained in the hospital 17.2 days. Fifty-eight patients with non-perforated gangrenous appendicitis in whom drainage was not used had an average hospital stay of 16.7 days; 42 patients in this same group in whom drainage was used had an average stay of 15.6 days.

In the next two groups, namely those in which perforation had occurred and those that presented appendiceal abscess, no such comparison was necessary because very few cases in these groups were undrained, in conformity with general opinion.

These figures show conclusively that drainage prolonged the hospital stay in the first two groups. In our series an average increase of 3 days in the period of convalescence occurred when drainage was used. In the group of non-perforated gangrenous appendicitis, the average hospital stay of the drained cases was apparently shorter than that of the undrained cases. This can be explained by the fact that the 2 mortalities in this group occurred in 2 drained cases and death occurred on the second and fourth days. Although the 2 patients who died had drainage, the number is insufficient to draw general conclusions. An additional fact to be considered is that the patients with drainage all left the hospital with some degree of discharge from their wounds and on this score undoubtedly had a longer convalescence than those not having drainage. Generally, with the passing of time, fewer patients in the group of non-perforated gangrenous appendicitis are being drained. Drainage is now practically limited to patients with perforation or abscess.

As a point of interest, the Battle-Kammerer incision was used in all but 1 case.

There were two methods of treatment of the appendiceal stump, namely, non-peritonealiza-

tion of the stump and peritonealization by means of a cuff, except in 10 cases in which a pursestring suture was used. We were unable to discover any significant changes in the postoperative course that could be attributed to the variations in the treatment of the appendiceal stump.

COMPLICATIONS

A study was made of the various complications that arose in relation to the pathology found in the appendix in order to see in which type of case the various complications were more frequent. The following paragraphs will be devoted to an enumeration of these complications in relation to pathological headings previously used in this paper.

The first complication studied was infection of the wound. The criterion of an infected wound was the presence of bacteria in the fluid obtained from the operative wound. Wound infections were directly proportional to the seriousness of the infection in our series, occurring in 5.2 per cent in group I, in 9.5 per cent in group II, in 14 per cent in type IIIA, in 28.8 per cent in group IIIB, and in 15.5 per cent in group IV.

Of course patients in whom drainage was instituted would be more likely to develop an infection of the wound due to the possibility of organisms being disseminated from the drainage tract into the various abdominal layers. In spite of this, however, the relatively higher percentage of infections speaks for the probability of the wound being infected by the operator's hands or by instruments at the time of operation. We feel that all the layers of the abdominal wall should be protected during the entire operation in order to minimize contamination of the wound.

Postoperative ileus occurred in 9 cases which represents 1.4 per cent of the total series. Of these 9 patients, 3 died. Fourteen patients developed a postoperative abscess which required subsequent drainage. Of this group 3 were in patients with acute appendicitis, 4 in patients with acute appendicitis with local peritonitis, and 7 were in patients who had an abscess at the time of operation. Pylephlebitis and multiple liver abscesses occurred in 4 patients, all of whom died. Two were in patients with gangrene and perforation of the appendix, and the 2 others were in cases of appendiceal abscess. There was one case of subphrenic abscess in a patient with a perforated gangrenous appendix. Embolization of the pulmonary artery occurred twice but was not fatal. Atelectasis occurred in 2 cases. Phlebitis as a complication occurred 5 times. Pneumonia occurred in 7 patients. One of these patients developed an empyema of the chest that had to be drained. Hemorrhage from the wound occurred in 3 patients and in 1 case was a contributory cause of death. Evisceration occurred three times without fatality. Fecal fistulas occurred in 4 cases of abscess but all closed spontaneously.

DISCUSSION OF MORTALITIES

Although the mortality rate for the whole series is 2.2 per cent and compares favorably with other reports, we feel that an analysis of the deaths on the basis of the pathological groupings used in this paper is worth while and would tend to dispel the optimism that might be created by this low mortality (Table II).

TABLE II.—MORTALITY ACCORDING TO PATHOLOGICAL GROUPS

	Cases	Deaths	Mortality per cent
Acute appendicitis	191	0	0
Acute appendicitis with local peritonitis	200	0	0
Gangrenous appendicitis:			
Non-perforated	101	2	2.0
Perforated	52	7	13.4
Appendiceal abscess	91	6	6.6

We are of the opinion that the incorporation of a separate group of cases of spreading peritonitis would offer a better classification of acute appendicitis.

To determine accurately the cases that could belong to such a group would be difficult, because such a diagnosis depends too much upon the personal impression of the operating surgeon. It is not unusual to see cases in which the interpretation at the time of operation was that of a severe spreading peritonitis. In many of these cases, the postoperative recovery was so rapid and uneventful that the interpretation at operation appeared doubtful. On the other hand, the experience of finding a relatively mild peritonitis at operation with ensuing postoperative reaction that was more befitting a case of spreading peritonitis, was frequent enough.

Those patients who presented free pus in the peritoneal cavity undoubtedly included all the cases of spreading peritonitis. Computing our mortality on the basis of this group alone, we arrived at the following: in the group of nonperforated gangrenous appendicitis, there were 9 cases with 2 deaths, a mortality of 22.2 per cent; in the group of perforation and gangrene of the appendix, there were 25 cases with 7 deaths, a mortality rate of 28 per cent; and in the group of appendiceal abscess, there were 19 cases with 6 deaths, a mortality rate of 31.6 per cent.

SUMMARY AND CONCLUSIONS

A series of 635 cases of acute appendicitis operated upon during a 5 year period was discussed from the viewpoint of etiology and factors in mortality and pathology. The total mortality for the whole series of cases was 15, or 2.2 per cent.

This represents an unselected group of cases, the operations being performed by about 70 different surgeons, including 20 house surgeons.

The technique must be as meticulous as in any major abdominal operation. None of the mortalities in this series could be attributed to the house officers as the patients upon whom they operated were all selected and a member of the attending staff always assisted at operation.

Since the object of this paper has been to analyze the mortality in acute appendicitis, we have discussed those factors which have contributed to mortality and have found the important factors to be the duration of the disease and the use of cathartics. Diabetes was also found to be a serious complication.

The element of time cannot be overstressed, for the profession and the public should be made to realize the seriousness of waiting in these cases. In a few patients the lesions progressed very rapidly, but these were the exception.

From our study we can definitely assert that cathartics increase the severity of the disease. The fact that the taking of cathartics will increase the risk of a fatal outcome in acute appendicitis should be more forcefully brought to the attention of the public.

There should be no temporizing in cases suspected of being acute appendicitis when diabetes is a complicating factor because the pathological process advances with great rapidity in such cases.

The group that produced the highest mortality in the series was that of gangrenous appendicitis with perforation. This is in complete agreement with the experience of others as reported in the literature upon this subject. Early operation and the omission of cathartics will prevent the progress of the disease to the state of gangrene or perforation and thus the mortality will be lowered. The problem of treatment in such cases, however, is still far from solved. Since it is a general rule in our hospital to operate immediately when the diagnosis of acute appendicitis has been established, we are not in a position to evaluate other methods of treatment.

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SOME EXPERIMENTAL AND CLINICAL ASPECTS OF THE USE OF HEPARIN

THE recent demonstration by the Toronto group that heparin is not only an anticoagulant but is also a preventive of thrombosis and that in purified form it has been administered to living animals without injurious reaction has brought this drug to a position of great practical, clinical importance.

The first experiments to investigate the effect of heparin on thrombosis were done by producing thrombosis in peripheral veins in control animals. By means of heparin this thrombosis could be prevented in a high percentage of cases. Arterial anastomosis was successful in a much higher percentage when heparin was used. Venous grafts, which invariably became occluded when heparin was not used, remained patent when successful experiments were completed. This is the first event in which venous grafts could be used successfully. Shionoya's experiment with an extracorporeal loop also provided further evidence of the effect of heparin in preventing thrombosis, as these tubes would remain clear so long as the clotting time was kept well elevated with heparin. Cardiac valves were placed experimentally in animals' hearts quite successfully, when heparin was used. Artificial emboli which caused severe reactions in the walls of the containing vessels, could be removed successfully and the vessels kept patent when heparin was used. In numerous experiments on the portal system, heparin was shown to be effective in preventing thrombosis. Organs were transplanted and the result was successful in a high percentage of cases when the drug was used. Best and Solandt demonstrated that coronary arteries which became occluded after injecting sclerosing solutions could be kept patent with the use of heparin. The mural thrombus, which forms rapidly on the infarcted area, was also prevented when heparin was given. These experiments by Murray combined with the evidence obtained from many clinical tests proved satisfactorily that heparin would prevent thrombosis.

Multiple tests were also made to test whether or not heparin was toxic. As this substance went through its various stages of purification by Best, Charles, and Scott, its toxic properties gradually disappeared. When these workers finally succeeded in producing the crystalline barium salt of heparin, the toxic properties disappeared completely in animals.

With heparin in a purified form, which had been found to be non-toxic in animals and which had been proved to prevent thrombosis as well as clotting, it seemed that a

suitable time had arrived to make a clinical test. Earlier clinical tests by other workers with less purified heparin revealed the fact that the drug was fairly toxic, but we hoped to find that this more purified form would be free from these ill effects. In a clinical test by Murray, MacKenzie, and Wilkinson, in more than four hundred patients there were no sensations from its administration and there were no thermal or other untoward reactions. Clotting times varying from twelve to thirty minutes were obtained regularly with no ill effects. Recently a slight modification of the technique of producing heparin had apparently changed the substance somewhat, as there were febrile reactions in about half the patients receiving it. More recently these toxic effects have again been eliminated. Several patients have received heparin on more than one occasion and there has been no anaphylaxis in any of them.

Heparin is given by a continuous drip through a steel needle lying in a superficial vein. In these four hundred patients, even though the needle was left at the same site in the vein for periods up to two weeks, there has been no thrombosis in these veins. This in itself is strong proof of the effectiveness of heparin in preventing thrombosis in human beings. Crawford and Jorpes have obtained good results by intermittent intravenous injections.

With the use of heparin, twelve clinical embolectomies have been done. When the obstruction of the vessels was relieved, all of these vessels remained patent and the clinical results were entirely satisfactory. This is in great contrast with former embolectomies and with other palliative methods of treatment which were followed by gangrene in a high percentage of cases.

As pulmonary embolism is a common postoperative complication and as it has been proved that heparin would prevent thrombosis, it was used in a group of cases after operation. There were more than three hundred in this group and while the number is too small from which to draw final conclusions, it is an interesting observation that none of the patients developed thrombosis or embolism even though many of them had undergone the types of major surgical operations which are prone to develop thrombosis and embolism. Hematomas occurred in five cases but none of these were of serious proportions and all the patients recovered. As it has been demonstrated experimentally that heparin will not dissolve or loosen a clot, it is obvious that in such cases vessels were left, which should have been ligatured. In ordinary good surgery when the large and medium sized vessels are tied off, heparin will not cause a hematoma. The bleeding from a capillary bed is not prolonged by heparin and the ordinary clotting processes act on these surfaces and are not changed by the presence of the moderately prolonged clotting times which are used in these clinical cases.

As thrombosis is at least one factor in thrombophlebitis, a group of seventy-two patients with this disease were treated with heparin. The improvement in the clinical course was impressive. The pain, temperature, and edema subsided much more rapidly than in a control group of cases. On the average, these patients were treated for one week to ten days, at the end of which time they were out of bed exercising actively and able to be discharged from the hospital. In these cases the clotting time is elevated to about three times the normal level, varying between fifteen and twenty minutes. Future work may show that some other level may be the optimum but to date this has been a quite satisfactory level.

In twenty-six of these patients pulmonary embolism had occurred. Many of these had massive embolisms giving the clinical picture of a patient *in extremis* from this disease. Before treatment of these patients was undertaken, the possibility of further embolisms was considered, because a venous system in which active thrombosis is taking place, almost certainly contains other thrombi, which may become detached at any moment. While the group of cases is too small from which to draw conclusions it is interesting that none of these twenty-six patients died of embolism. One, or possibly two might have had further small embolisms within the first few hours after treatment was begun but this was not proved. The remainder of the patients made a rapid recovery with early marked relief of the respiratory and cardiac distress, as well as relief of symptoms from the peripheral thrombophlebitis present in most of them. It is interesting to note that other workers, Olsen and Chargaff, have had similar experience with this type of case. While there is insufficient evidence so far to advocate general use of heparin for this disease, it is worth further investigation, especially as palliative methods only, apart from operation, are available otherwise.

The high mortality rate from progressive thrombosis in cases of mesenteric thrombosis involving a sufficient length of bowel to require surgical resection, seemed to present a challenge to the effectiveness of heparin in the portal system. It was with great satisfaction that Murray and MacKenzie observed the recovery of the first four cases of this disease, in whom from two to seven feet of bowel had been resected, followed by treatment with heparin. These patients are alive and well today for periods varying from nine to eighteen months. Two other patients who were treated with heparin died, one of bronchopneumonia and the other of peritonitis. Postmortem examination in both of these showed that there was no extension of thrombosis and that the intestine was viable. This was one of the most important and critical clinical tests of the effectiveness of heparin.

In a few cases of splenectomy for familial jaundice and other lesions in which portal thrombosis causes a high mortality, heparin has also been used successfully and no thrombosis has occurred.

In coronary and cerebral thrombosis, there is a possibility that heparin might be of value in preventing the extension of the disease. There have not been enough of these patients treated to know what effect heparin might have. In vegetative endocarditis when infection and thrombosis are combined, there is the possibility that heparin might control the thrombosis and, combined with a blood sterilizing drug, this disease might be cured. The number of patients treated in Toronto is too small to draw conclusions, and this, as most other stages of this work must still be considered to be in the experimental stage, even though encouraging results have been obtained elsewhere. In cavernous and lateral sinus thrombosis as well as in osteomyelitis when septic emboli are discharged, heparin has appeared to be of value. The number of patients treated is too small to draw conclusions.

In blood transfusions, heparin has been used quite satisfactorily either by adding the drug to the blood as it is withdrawn, or by giving the donor a sufficiently large dose to change the clotting time of his blood. The results have been satisfactory with both methods.

It is interesting that in one clinical case, Murray placed the external jugular vein as a graft, in a gap in the popliteal artery and with

heparin treatment the graft remained patent and functioned as part of the arterial system. Several end-to-end anastomoses of main arterial trunks have been done successfully in patients, and these have remained patent with the use of heparin. This opens the way for a wide application of this principle in many injuries and diseases of the vascular tree, which were formerly treated by ligation with disastrous results in some. While this work is still in the experimental stage, evidence is rapidly accumulating to show that heparin is of great value in dealing with injuries, thrombosis, and diseases involving blood vessels. It probably has opened a new vista in the treatment of these lesions.

D. W. GORDON MURRAY.

TREATMENT OF CHOLEMIC BLEEDING

COMPETENT authorities have said that further improvements in the effectiveness of surgical procedures and reduction in the surgical mortality would be brought about chiefly by studies on the pathological physiology of diseases requiring surgical treatment. This type of work has been prosecuted with special vigor in recent years and in many fields notable improvements in surgical results have been accomplished. One of the most interesting advances in this direction during the past few years has been made concerning the enigmatic problem of cholemic bleeding.

During the past three years several groups of investigators in this country[1, 2] and abroad[3] independently have demonstrated that in most cases of jaundice or of primary hepatic injury a deficiency of prothrombin exists in the circulating blood which can be corrected by the administration of concentrates containing vitamin K. Several of these authors have pointed out carefully that cases of severe hepatic damage are encountered occasionally in which there is no response to treatment with vitamin K and that treatment in general is accompanied by many serious pitfalls which can be overcome only by alertness and basic physiological knowledge of the whole problem.

Several investigators have noted that in the course of treatment of patients with hypoprothrombinemia, vitamin K frequently cannot be taken by mouth. The products formerly available were not suitable for effective parenteral administration and a more pure product obviously was needed to supply adequate material for parenteral administration and to eliminate those unknown substances, other than vitamin K, which were being given when concentrates of alfalfa were employed.

The clinical application of recent knowledge concerning vitamin K has been dramatic, but equally so have been the results of study of the chemistry of vitamin K. During the past year vitamin K_1 has been isolated in pure form from alfalfa and synthesis has proved it to be 2-methyl–3-phytl–1, 4-naphthoquinone.[4] A vitamin K_2 also exists and can be extracted from fish meal but its structure as yet has not been determined. Several synthetic compounds, possessing high antihemorrhagic activity, also have been discovered and of these compounds, phthiocol and 1, 4-dehydroxy–2-methyl–3-naphthaldehyde administered intravenously and 2-methyl–1, 4-naphthoquinone administered by mouth have proved to be useful clinically. Of these compounds 2-methyl–1,4-naphthoquinone possesses an antihemorrhagic activity nearly equal to that of pure vitamin K_1 and for patients with hypoprothrombinemia this compound is effective in daily doses as small as 1 or 2 milligrams when

[1] WARNER, E. D., BRINKHOUS, K. M., and SMITH, H. P. Proc. Soc. Exper. Biol. & Med., 1938, 37: 628–630.
[2] BUTT, H. R., SNELL, A. M., and OSTERBERG, A. E. Proc. Staff Meet., Mayo Clin., 1938, 13: 74–30.
[3] DAM, HENRIK, and GLAVIND, JOHANNES. Lancet, 1938, 1: 720–721.
[4] BINKLEY, S. B., MACCORQUODALE, D. W., THAYER, S. A., and DOISY E. A. J. Biol. Chem., 1939, 130: 219–235.

administered by mouth together with animal bile salts. This product is not soluble in water and further studies will determine whether or not it can be used parenterally. The compound is simple, fairly stable and possesses a high antihemorrhagic activity. Because of these qualities, adoption of this compound as a standard for vitamin K has been suggested.

The various synthetic products, no doubt, will soon replace the more crude but effective concentrates of vitamin K now used and the availability of standardized materials which can be administered orally or intravenously give hope that surgical mortality attributed to cholemic bleeding itself will be relegated to the surgery of the past. It is perhaps well to remember that the discovery of thyroxin gave hope in the past that the cruder thyroid extract would soon be replaced, but time has proved otherwise. It may be wise to continue the use of the old but tried concentrates of vitamin K which are known to be effective and without untoward reactions until the newer synthetic products have received wider clinical and experimental investigation.

HUGH R. BUTT.

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REVIEWS OF NEW BOOKS

THE latest volume containing the proceedings of the New York meeting in 1937 of the *Association for Research in Nervous and Mental Disease*[1] is the eighteenth consecutive volume in an imposing group of research publications. This entire series has been meritorious for its continuous presentation of new and reliable data of fundamental importance, and the present volume is no exception to this precedent.

A division of the material into three sections, namely, anatomy and physiology, pathology, and clinical contributions, makes natural the correlation of newer morphological concepts of the circulation of the central nervous system to disease states, and the application of constantly new methods of treatment. Particularly provocative are the questions which Bronk, Gerard, and others have raised concerning the effect of anoxia, oxygen availability, brain metabolism, in fact, the alterations of cerebral circulation. In a discussion of the hematoencephalic barrier, i.e., the blood-brain barrier, King has reviewed the concept of "endothelial barrier" as opposed to the concept of "lack of affinity," and on the basis of his vital staining experiments he accepts the latter theory as the one responsible for the failure of the brain to stain with trypan blue. That is, the impermeability of the endothelium of the cerebral capillaries is not the cause of the failure of the brain to stain; rather, the failure of the subjacent glial tissue in the brain to attract the dye, as opposed to the affinity between stain and connective tissue in the other vascular beds of the body, accounts for the cerebral blood barrier. His paper opens up several lanes of thought even if it does lack complete finality of proof.

The book contains an outstanding chapter by Soma Weiss on the regulation and disturbance of the cerebral circulation through extracerebral mechanisms in which there is a comprehensive review and discussion of the rôle of the carotid sinus, and of syncope, circulatory failure, shock, and cerebral anoxia caused by factors other than the carotid sinus in the production of many well known clinical syndromes related to abnormal cerebral circulation. This chapter is replete with facts and suggestions of clinical application and importance.

This eighteenth volume does not, of course, settle all questions arising from our lack of knowledge of the nature of the cerebral and spinal circulation and the pathological entities attendant thereon. But it does represent a convergence of theory, experiment, and practice; it is an exposition of much new and fundamental knowledge of the morphology and physiology of the vascular tree in the central nervous system; and it is, above all, the result of co-ordinated research effort.

JOHN MARTIN.

[1] ASSOCIATION FOR RESEARCH IN NERVOUS AND MENTAL DISEASE. Vol. 18 of a Series of Research Publications. The Circulation of the Brain and Spinal Cord; a Symposium on Blood Supply. The Proceedings of the Association, New York, December 27 and 28, 1937. Baltimore: The Williams & Wilkins Co., 1938.

THE authors have completely revised the third edition of *Lehrbuch der Roentgendiagnostik*.[2] Nearly every specialty has developed a massive text in which one may find boiled down to the briefest space compatible with practical value the sum total of knowledge relating to its particular field of medicine. Here we have such a fund of knowledge concerning radiological diagnosis. The text does not include any discussion on roentgen therapy, but the preliminary sections present a very detailed exposition of the physical laws relating to x-rays, fluoroscopic screens and x-ray films, and the general principles of roentgenography. For details of radiographic technique, the reader is referred to the appropriate books of technical instruction.

The two volumes represent the highest mark yet attained in the production of roentgen diagnostic texts. The first volume deals entirely with bones and joints; the second with internal medicine. When it is realized that nearly 1,000 pages are devoted to the radiology of bones and joints, the skull and its contents, the facial accessory sinuses, and the teeth, he will appreciate the tremendous labor involved in the production of the first volume. The text is unusually well done; only here and there are seen evidences of haste. The illustrations are as nearly perfect as could be expected.

The second volume deals with the thorax and its contents, followed by the digestive tube, the biliary tract, the urinary tract, and roentgen considerations of obstetrical and gynecological diagnosis. The 1,200 pages of the second volume match the first in evidence of great care in revision, so that all the new material on mucosal relief, kymography, tomography, etc., is included.

The authors and the publisher merit our gratitude for such a splendid text.

JAMES T. CASE.

THE booklet of 57 pages from the *Privy Council Medical Research Council*[3] is based on a statistical study of the mortality of appendicitis in England and in other countries. Such a report should be of particular concern to those who are interested in the study of appendicitis.

Many factors are investigated, such as relation of the mortality of appendicitis to age, sex, marital

[2] LEHRBUCH DER ROENTGENDIAGNOSTIK. By H. R. Schinz, W. Baensch, and E. Friedl. 4th enl. rev. ed. Vol. 1—Skelett. Vol. 2—Innere Organe. Leipzig: Georg Thieme, 1939.

[3] PRIVY COUNCIL MEDICAL RESEARCH COUNCIL. Special Report Series, No. 233. Appendicitis; A Statistical Study. By Matthew Young and W. T. Russell. London: His Majesty's Stationery Office, 1939.

state, seasonal incidence, and the problem of diet. Regional distribution and the relation of appendicitis to urbanization are also studied. There is no great variation between the mortality rates of England and America. Further, a decrease is shown in the case fatality of appendicitis despite an apparent increase in the incidence of the disease. This report points out the great increase in the mortality of appendicitis in the extremes of life while in the middle decades there is a decrease. The mortality rate for the higher social class is found to be about two and one half times greater than for the poorer social class. Although at the first reading this report seems a maze of statistical data, a more careful study discloses many interesting points concerning the mortality of appendicitis. HARVEY S. ALLEN.

THE phyletic variations of the brachial plexus is discussed by Wilfred Harris in his unique monograph entitled *The Morphology of the Brachial Plexus*.[1] The book represents the conclusions of almost 40 years of meticulous work on a wide variety of animals, some of which because of their rarity had been obtained for study with great difficulty. The material presented is based on the author's dissection of the brachial plexus in 158 cases (on both sides in some specimens) divided as follows: 30 human beings, 6 anthropoid apes, 37 monkeys, and 85 other animals and birds, including all classes above fishes from amphibia and reptiles to primates. The arrangement of the dorsal and ventral divisions of the nerves with their branches, running in consistent patterns to the dorsal and ventral components of the limb buds, led the author to believe that it is highly probable that the neuromuscular supply in different animals is a most useful, if not invariable, guide to muscular and nervous homologies.

The plexus is simplest in the anuren with only the 3 upper spinal nerves contributing; it is most complex in the primates. There is a brief discussion of the Fuerbinger theory that a muscle is to be regarded as the end organ of a nerve, and a brief treatise is added on the gross structure of the pectoral muscle in mammals. The book is nicely illustrated by colored plates of the various types of plexuses, and each class of animals is treated by a separate and complete description. This monograph offers a ready and concise means for comparison of the plexus in the various phyla above the frog, and should prove to be of special use and interest to comparative anatomists and teachers of anatomy.

JOHN MARTIN.

FROM the preface one learns that *Clinical Pathological Gynecology*,[2] consisting of 373 pages and illustrated with 271 engravings, is an introduction to the subject. It is intended to give students an insight into gynecological pathology and to assist in correlating clinical syndromes with the gross and microscopic pathology of diseases peculiar to women.

The contents have been arranged according to anatomical location rather than similarity of diseases. There are 13 sections, namely, pathology of the vulva, pathology of the vulvovaginal glands, pathology of the vagina, pathology of the cervix, anterior pituitary gonadotropic hormone, the ovarian hormones, menstruation and its disorders, gynecological disorders of early pregnancy, pathology of the endometrium, pathology of the myometrium, miscellaneous uterine disorders, pathology of the fallopian tubes, and pathology of the ovary. The sections on pathology consist of a few pertinent statements about the clinical signs and symptoms, a description of gross and microscopic pathology, and a few lines on treatment of each lesion considered. Most of the conditions are illustrated by drawings or photographs of the gross specimens, and photomicrographs. The sections on endocrinology are the outstanding features of this book. The subject matter is presented in a delightful style and it is conclusive.

Those of us who conduct courses in gynecological pathology are sorely in need of a textbook for students. Possibly it would be appropriate to offer some suggestions which might broaden the appeal of Witherspoon's book. The frequency of errors in proofreading is disconcerting. The original illustrations of gross specimens are photographs; most of them lack clarity and unfortunately none is reproduced in color. The quality of the photomicrographs is better but many of them should be replaced with more convincing illustrations. There is a lack of balance; 75 pages are devoted to pathology of the ovary, and 20 of these pages are consumed by the rare Brenner and special endocrinal tumors. This exceeds the space devoted to the frequent and highly important cystadenomas and carcinomas; in fact, it almost equals the space allotted to cancer of the cervix.

Under erosion of the cervix one reads, "Whatever might be written in this text would only be a personal point of view and opposing evidence could be readily advanced to contradict the stated hypothesis. Whenever such debatable and unsettled problems are encountered, the policy followed in this book is to make no dogmatic statement but to let the reader judiciously choose his own side of the question." Such an attitude is commendable but the sections on endometriomas and uterine fibromyomas reveal marked deviation from this policy.

GEORGE H. GARDNER.

THE second edition of *Textbook of General Surgery*,[3] by Warren H. Cole, of Chicago, and Robert Elman, of St. Louis, has been published

[1] OXFORD MEDICAL PUBLICATIONS. THE MORPHOLOGY OF THE BRACHIAL PLEXUS; WITH A NOTE ON THE PECTORAL MUSCLE AND ITS TENDON TWIST. By Wilfred Harris, M.D., F.R.C.P. New York and London: Oxford University Press, 1939.

[2] CLINICAL PATHOLOGICAL GYNECOLOGY. By J. Thornwell Witherspoon, B.S., B.A., and M.A. (Oxon.), M.D. Philadelphia: Lea & Febiger, 1939.

[3] TEXTBOOK OF GENERAL SURGERY. By Warren H. Cole, M.D., F.A.C.S., and Robert Elman, M.D. 2d ed. New York and London: D. Appleton-Century Co., Inc., 1939.

recently by the D. Appleton-Century Company of New York. The original edition was the outgrowth of a course of lectures given during a period of 8 years while the authors were at Washington University Medical School and, therefore, was especially designed for medical students.

The subject matter has been presented from the physiological point of view with emphasis on surgical pathology and the general principles underlying surgical procedures. Great detail in the technique of operations has been omitted purposely in order that the more important things might be covered within the scope of a single volume. The second edition has brought to the student and practitioner of surgery a consideration of the very latest advances in a field where rapid progress is being made, and to this the editors themselves have richly contributed.

EDWIN M. MILLER.

THE eleventh edition of *Pye's Surgical Handicraft*[1] has been recast and prepared by Hamilton Bailey. The first volume appeared 54 years ago. This volume corresponds in many ways to what is known in this country as "minor surgery," but in England it is known as a "manual of surgical manipulations, minor surgery, and other matters connected with the work of house surgeons and of surgical dressers."

Twenty-eight contributors help to make up this volume which contains chapters on practically every specialty in medicine and surgery, as well as briefer chapters by the nursing, legal, and dental professions. Each chapter is concise, well written, but in many instances rather superficial. Practically everything that might confront an interne or resident during his hospital stay is covered in this volume of 475 pages.

All in all, I would not hesitate to recommend the book to the interne beginning his hospital training; I am of the opinion, however, that several of the minor surgery books, published in this country, cover the subject more thoroughly.

EARLE I. GREENE.

ACCORDING to the author, *Cancer Handbook of the Tumor Clinic*[2] is a brief, practical treatise designed for a graduate course, and presents the views and methods practiced in the Tumor Clinic of Stanford University. The booklet is a revision of a syllabus on the diagnosis and treatment of cancer published originally in 1937.

The manual opens with a discussion of the cancer problem and is followed by a chapter on the principles of radiation therapy. The other chapters deal with cancer of various organs. The treatise contains much valuable and interesting information about cancer. The booklet is nicely compiled and the material is well arranged. Some of the photographs, especially those of melanomas of the conjunctiva and iris, are excellent. The author has undoubtedly succeeded in presenting some useful information on cancer in the brief space of 100 pages; but it is suggested that more care might be given to the selection of the bibliography in future editions.

MAX CUTLER.

THE book entitled, *The Endocrine Glands*,[3] is valuable. The author has had prolonged experience in clinical endocrinology. To this personal advantage is added an exhaustive presentation of references with each subject discussed. These references are introduced between sections of the text, a convenient form of arrangement which brings the literature to the immediate attention of the reader. History, pathology, and physiology are thoroughly discussed in each chapter. Many photomicrographs of the pathological histology of the endocrine glands are included. The author's views on treatment are given throughout, sometimes at variance with more generally accepted views, but these also are presented in full.

PAUL STARR.

THE work of William Wolf entitled *Endocrinology in Modern Practice*[4] is a large book and is evidently an attempt to present endocrinology to practitioners of medicine who may not have other references available. For such readers it is unfortunate since the subject is presented in a falsely suggestive manner. The discussion of many subjects is diffuse, including debatable material that is not critically debated and not documented in any way. Isolated reports of success with questionable procedures are given as suggestions for treatment in a manner that is quite like informal clinical gossip. This can lead only to the disappointment of the doctor and his patient and to the discredit of endocrinology.

After the presentation of endocrine diseases, 141 pages of unfounded speculation as to the possible endocrine factors in internal medicine are produced. Valvular heart disease, it is claimed, may be caused by diabetes with decided improvement when active antidiabetic treatment is given. An alphabetical catalogue of symptoms and their possible endocrine causes is given, such as pain in arm, Dercum's disease, hyperthyroidism, angina pectoris, brachial neuritis, rheumatism, fibrositis, myositis, and trauma.

The wholly misleading and unreliable catalogue of endocrine products, in which material for oral administration is given as prominent a place as potent injectible material, is again included. No evaluation is attempted. The American public must spend thousands of dollars annually on much of this

[1] PYE'S SURGICAL HANDICRAFT; A MANUAL OF SURGICAL MANIPULATIONS, MINOR SURGERY, AND OTHER MATTERS CONNECTED WITH THE WORK OF HOUSE SURGEONS AND OF SURGICAL DRESSERS. Edited by Hamilton Bailey, F.R.C.S. (Eng). 11th ed. Baltimore: The Williams & Wilkins Co., 1939.

[2] CANCER HANDBOOK OF THE TUMOR CLINIC, STANFORD UNIVERSITY SCHOOL OF MEDICINE. Edited by Eric Liljencrantz, M.D. Stanford University, Calif.: Stanford University Press, 1939.

[3] THE ENDOCRINE GLANDS. By Max A. Goldzieher, M.D. New York and London: D. Appleton-Century Co., Inc., 1939.

[4] ENDOCRINOLOGY IN MODERN PRACTICE. By William Wolf, M.D., M.S., Ph.D. 2d rev. ed. Philadelphia and London: W. B. Saunders Co., 1939.

medicine, the prescription of which is dishonest to the patient and disappointing to the doctor. It is unfortunate that it should be recommended in this publication. PAUL STARR.

THE second edition of *Sex and Internal Secretions*[1] is the result of the collaborative efforts of 27 American authorities on the fundamental problems of sex. Each contributor has again reviewed, digested, and evaluated the fast-moving field of his special interest. In this way the results of thousands of articles are reduced to comprehensive surveys linked with working bibliographies. The value of these labors to students, practitioners, and investigators is incalculable, since even a specialist can scarcely hope to keep pace with the progress in more than a few of the topics covered. No book exists in any language to challenge the supremacy of this work in authoritativeness or comprehensiveness.

Five major sections treat the following subjects: (1) the biological basis of sex; (2) the physiology of the sex glands, germ cells, and accessory organs; (3) the biochemistry and assay of gonadal hormones; (4) the hypophysis and the gonadotropic hormones of the blood and urine in relation to the reproductive system; and (5) additional factors in sex functions and endocrine applications in man.

Several new contributors cover certain closely related subjects which have made unusually rapid progress. Notable is the inclusion "of all the experimental evidence concerning the endocrinology of sex function that is largely due to the great advances made in the chemistry of male and female hormones, and to the extensive study of the many functions of the pituitary, and of the interrelations between endocrine glands."

To review adequately this monumental publication would doubtless be a challenge even to its editor. The present reviewer must limit his remarks to praise and gratitude for an accomplishment well conceived and admirably carried out. It is certain that the enthusiasm with which the first edition was received and the popularity which it deservedly merited will be extended to the new edition. This may be predicted with confidence because so many improvements and changes have entered that the former edition, after only 7 years of service, becomes to a large degree obsolete. In size alone 400 pages have been added to this second edition.

National pride will be gratified in observing how extensively and intensively American investigators have contributed to this field. Our country has become the center in which the most important discoveries from the newer attack in sex problems have been made. Still more remarkable is the degree to which anatomists, zoologists, and chemists have taken over this field. This trend is reflected in the roster of collaborators which includes but one physiologist and two clinicians. L. B. AREY.

[1]SEX AND INTERNAL SECRETIONS: A SURVEY OF RECENT RESEARCH. Edited by Edgar Allen, Charles H. Danforth, and Edward A. Doisy. With forewords by Robert M. Yerkes. Baltimore: The Williams & Wilkins Co., 1939.

THE publication, *Varicose Veins*,[2] is fully up to the standards long since set by these prominent medical writers. The work is condensed and to the point, yet the authors have not lost sight of the important subjects which are well covered.

The chapter on anatomy discusses the veins of the lower extremity in great detail which makes it easier to link up later the chapters on pathology of varicose veins and their treatment. Though the chapter on pathology of treated varicose veins is short, it makes the subject very clear and definite.

The authors have given more than usual space to the examination of the patient. This is justly so for it is probably the most important part of the treatment of varicose veins. This chapter is very replete with photographs and drawings which together with their tests make the study of the venous flow in varicose veins very clear and positive.

The chapter on treatment, which is particularly good, follows the principles and theories developed over a long period of time and portrays a large volume of work both clinical and private. However, the chapter on varicose ulcer is very short and not up to the standards of the rest of the book. The authors seem less impressed with this complication.

It is a book well worth perusal by any one at all interested in this subject. H. O. MCPHEETERS.

THE second revised edition of *A Textbook of Surgery*[3] has appeared 3 years after the first edition was printed. The book is divided into 40 sections or chapters dealing with all branches of surgery. There are some 190 co-authors to the book which is 1,695 pages in length. The co-authors are active teachers and practitioners of surgery at the present time, and the book represents an up-to-date opinion upon modern surgery. A number of recent changes in surgical opinions both as to therapy and surgical procedures are added by several new contributors of note. The editor has used good judgment in selecting his contributors, and with few exceptions has selected outstanding authorities upon the various subjects.

The new edition is quite timely as are all new editions of medical books. One would expect it to be possible to record more readily and accurately the rapid changes in surgical opinion and progress in a book of this kind with its many authors than in the ordinary textbook. It has many advantages over the usual textbook on surgery which contains so much repetition of previous editions. At the present time, with the intensive specialization, it is impossible for one or two authors to be qualified to do justice to all branches of surgery or even to a few of the specialties.

As a reference book for the surgeon, graduate student, general practitioner, or even the internist, it

[2]VARICOSE VEINS. By Alton Ochsner, B.A., M.D., D.Sc. (Hon.), F.A.C.S., and Howard Mahorner, B.A., M.D., M.S. (Surgery), F.A.C.S. St. Louis: The C. V. Mosby Co., 1939.

[3]A TEXTBOOK OF SURGERY. By American Authors. Edited by Frederick Christopher, B.S., M.D., F.A.C.S. 2d ed. rev. Philadelphia and London: W. B. Saunders Co., 1939.

fills a great need in the rapidly changing surgical knowledge and practices. There may be some question as to its value to medical students as a textbook because of its exhaustive character; but for collateral reading and reference it is a great convenience, eliminating much lost motion used in searching the current medical journals. No practicing surgeon can afford not to have the book available for needy reference.

Let us hope its editor will continue the practice of frequent revisions as the occasion arises.

ALBERT O. SINGLETON.

THE author of *Proctology for the General Practitioner*[1] has written a 375 page book especially designed to meet the needs of any general practitioner. It is a practical manual offering explicit and ready reference for the day to day problems in anorectal diseases.

In spite of the publication during the past two years of several very good volumes on rectal surgery, this book will fill a long vacant place in the general practitioner's library. It is definitely not a book for the proctologist or the general surgeon who is well grounded in the principles of rectal surgery. Unlike many recent books on this subject, which lead the general practitioner to believe he can treat all rectal conditions in his office, the author points out those conditions which are definitely not suitable for office care. Controversial matter and subjects of no real benefit to everyday practice have purposely been omitted.

One of the most useful chapters in the book is entitled "Anorectal Symptomatology." Bleeding, pain, protrusion, discharge, bowel habit, and anal itching are analyzed from the causative point of view. This should enable the practitioner, who does not frequently come in contact with rectal pathology, to make differential diagnoses.

History and examination are given adequate emphasis for this type of book. The endoscopic pitfalls, errors, and dangers of snap diagnoses are pointed out. The examination, from external inspection to sigmoidoscopy, is described with a running reference to the pathological conditions usually found in the various divisions of the anus and rectum. Pictures of instruments and proctological methods are freely utilized.

One chapter deals with the non-operative as well as the operative treatment of internal hemorrhoids. The author lists nine different solutions for sclerosing internal hemorrhoids. This is bound to be rather confusing to the occasional rectal therapist. However, in general the technique of hemorrhoidal sclerosis is ably handled. The clamp and cautery operation as described may give one the false impression that it is the operative procedure of choice.

There is a useful chapter on rectal, anal, and perineal symptoms of urogenital origin. As added features, chapters are included on constipation, diarrhea, parasites, and therapeutic suggestions. This last consists of formulas for enemas, irrigations, and methods of relieving anal pain.

THOMAS JAMES MERAR.

GROSS anatomy, the oldest and the most fundamental of the laboratory sciences contributing to medicine, finds itself today in the position of a pedagogical stepchild. From a traditional 1,000 hour course, it has in some quarters been compressed into a curtailed portion, managed by racy methods in one-fifth or even one-tenth of the original quota of time. Its hours have been reduced in number to make place for the new and necessary courses which teach technical methods essential to the specialities, for those which are designed to correlate the several divisions of a science, and for the courses which strive to bring into rational mental fabric the facts gleaned from laboratory and dispensary. Beleaguered by this enthusiastic medical soldiery, the anatomist finds it difficult to train his students with the old thoroughness. If he is to succeed in even the adequate discharge of this commission, the teacher of anatomy must put his students through their paces unhampered by any impediment, and give to the medical and surgical recruits only that information which is basic. In other words, it is necessary for the student to receive wise and skilled laboratory instruction, and books which are texts and not encyclopedias should be used.

In Professor Howell's *Gross Anatomy; a Brief Systematic Presentation of the Macroscopic Structure of the Human Body*[2] the teacher and student are presented with a treatise which is designed to meet these modern demands. The volume is concise, consisting of only one-third as many pages as the older books, yet it presents concepts as well as descriptive material. It has judiciously omitted histology and the microscopic portion of neurology; somewhat astonishing, and doubtless pleasing to some instructors, is the introduction of a proportionately large amount of comparative anatomical material.

Through much of the book the systematic accounts are handled with courageous brevity. In descriptions of the individual bones of the cranium, discussion of the complex articular relations is omitted; in the case of the long bones, the attachments of muscles are not presented with tedious detail; the section on each of the organs of special sense includes the accessory structures, that on the organ of sight, for example, including not only the eyeball, but the glandular, nervous, and vascular contents of the orbit, and the eyebrows and eyelids. In presenting the anatomy of the blood-vascular system similar brevity prevails; only the essential relationships of the larger trunks are given. The lymphatic glands and vessels are treated with un-

[1] PROCTOLOGY FOR THE GENERAL PRACTITIONER. By Frederick C. Smith, M.D., M.Sc. (Med.), F.A.P.S. Philadelphia: F. A. Davis Co., 1939.

[2] GROSS ANATOMY; A BRIEF SYSTEMATIC PRESENTATION OF THE MACROSCOPIC STRUCTURE OF THE HUMAN BODY. By A. Brazier Howell. New York and London: D. Appleton-Century Co., Inc., 1939.

usual conciseness; the relations of the organs of the digestive and the urogenital systems are handled likewise.

Pictures are the mainstay of *Gross Anatomy*. Without iconography, anatomy would be a devitalized science, lose much of its traditional attraction and discharge but a colorless half-service to its students in whatever century. The figures which Professor Howell uses are ingeniously diagrammatic and usually original in conception; they are supplementary to those available in regular atlases; and assumedly they are not intended to portray the details of anatomical dissections. Of the 56 illustrations in the textbook about half, or 27, are gross anatomical, several of these being purely schematic, 17 are embryological, 7 comparative anatomical, and 5 neurological. The figures portraying developmental anatomy should prove serviceable in helping the beginner to understand the form and disposition of structures as they are encountered in the adult body; those showing the reflections of the peritoneum, the transformation of the primitive venous system, the development of the pharyngeal glandular derivatives, are useful additions to an anatomical textbook although they are not new in concept.

The explanatory notes on terminology and topography will be of assistance to the novice, as will also those introductory paragraphs to each chapter which present general information on the bodily systems.

BARRY ANSON.

BOOKS RECEIVED

Books received are acknowledged in this department, and such acknowledgment must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers and as space permits.

OXFORD MEDICAL PUBLICATIONS. BLOOD TRANSFUSION. By Victor Horsley Riddell, M.A., M.D. (Camb.), F.R.C.S. (Eng.). London: Oxford University Press, 1939.

THE PARTICIPATION OF MEDICAL SOCIAL WORKERS IN THE TEACHING OF MEDICAL STUDENTS. Prepared by Harriett M. Bartlett for the Education Committee of the American Association of Medical Social Workers. Chicago, 1939.

HARVEY CUSHING'S SEVENTIETH BIRTHDAY PARTY, April 8th, 1939. SPEECHES, LETTERS, AND TRIBUTES. Published for The Harvey Cushing Society. Springfield, Ill.: Charles C. Thomas, 1939.

ACCEPTED FOODS; AND THEIR NUTRITIONAL SIGNIFICANCE. Chicago, Ill.: American Medical Ass., 1939.

OXFORD MEDICAL PUBLICATIONS. THOMSON & MILES' MANUAL OF SURGERY. By Alexander Miles, M.D., LL.D., F.R.C.S.Ed., and The Late Sir David Wilkie. Vols. 1 and 2. 9th ed. London: Oxford University Press, 1939.

SURGERY OF THE HAND: SOME PRACTICAL ASPECTS. By John Harold Couch, M.A., M.B., F.R.C.S. (Edin.). Toronto: The University of Toronto Press, 1939.

FISIOPATOLOGÍA DEL HEPATO-COLÉDOCO; COLANGIOGRAFÍA OPERATORIA. By Pablo L. Mirizzi. Buenos Aires: Librería y Editorial "El Ateneo," 1939.

A TEXT-BOOK OF GYNÆCOLOGY; FOR STUDENTS AND PRACTITIONERS. By James Young, D.S.O., M.D., F.R.C.S.E., F.R.C.O.G. 5th rev. ed. London: Adam & Charles Black, 1939.

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THE ESSENTIAL PRINCIPLES IN CLEAN WOUND HEALING

ALLEN O. WHIPPLE, M.D., F.A.C.S., New York, New York

DURING the past 4 or 5 years, as a result of the regular surgical staff conferences and carefully analyzed case records in many of our hospitals, there has developed a renewed interest in problems of wound healing. This is a very healthy attitude on the part of our profession, and one encouraged by the American College of Surgeons in its demands for accurate records and open discussion of complications and poor results in the surgical staff meetings in our class A hospitals.

Many articles have appeared in the surgical literature during this period attributing improvement in wound healing, especially in clean wounds, to one type or another of suture material, to some special technique, or to such measures as air sterilization in the operating room. With so many contributions to this subject it is difficult for the busy surgeon to read with discrimination, and it may be an opportune time to point out certain fundamental principles underlying the healing of wounds which must be borne in mind in the care of wounds, especially those that we, as surgeons, make in the course of our regular work.

From time immemorial man has been subject to trauma. The savage who had the temerity to attempt to stop the flow of blood and to close wounds caused by animal or human combat was looked upon with awe and respect. The first recorded accounts of human accomplishment depict the primitive surgery of the ancients. But it is only within comparatively recent time that the three dreaded terrors of wounds, hemorrhage, pain, and infection, have been controlled.

With the discoveries of anesthesia and bacterial cause of infection in wounds, general surgery made enormous strides. Following Lister's contributions in antisepsis and the more recent asepsis of the past 50 years, many surgeons—unfortunately, too many of the present day—have taken wound healing for granted if they conformed to the standard rules of accepted asepsis.

The essential principle of keeping out of the wound instruments, hands, sponges, and suture material that are not sterile has resulted in a marvelous improvement in wound healing the world over. But there has been too great a tendency to attribute wound healing, especially clean wound healing, to a special technique, or to one kind or another of suture material, or to some kind of air filtration or air sterilization in the operating room.

For this reason it seems an opportune time to call attention again to certain underlying principles in the repair of wounds which must be kept in mind constantly when the value of any one technique or any new addition to our surgical armamentarium for the repair of

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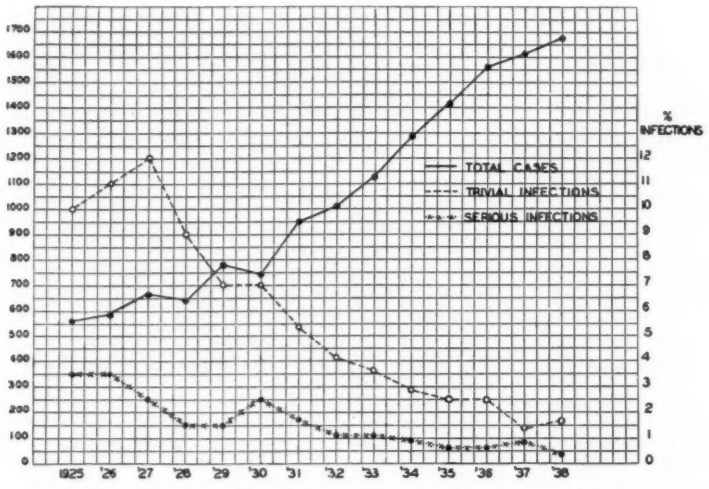

Chart 1. Showing the decreased percentage of infection in wound healing from 1925–1938.

wounds is considered. At the expense of seeming to be dogmatic and with apologies for presenting well known facts, these principles may be summarized as follows:

1. *Hemostasis.* Hemorrhage in the course of repairing a wound must be controlled if the apposition of the wound edges or surfaces is to be accomplished. A large blood clot, even if sterile, will delay the fibroplasia which unites the wound surfaces. But the control of bleeding must not be counteracted by the devitalization of tissue by the use of mass ligatures or heavy ligature material which favors infection and delays healing.

2. *Infection must be eliminated as far as possible.* (a) It is absolutely essential to exclude virulent pathogenic bacteria by the use of sterilized instruments and supplies, intact gloves—the boiled hand—and by the careful masking of mouth and nose, thus protecting the wound from the pathogenic organisms of the respiratory tract and oropharynx.

It is now generally recognized that the skin cannot be sterilized because of hair follicle and sweat gland bacteria not eliminated by any known germicide. But by careful preliminary cleansing with soap and water, followed by a chemical bactericidal solution, a relatively clean skin can be attained. Careful exclusion of the skin edges during the operation, and keeping out of the wound contaminated gloves, instruments, and salt solution will minimize the skin contaminants. The central salt solution bowl, used on so many operating tables to wash or wipe instruments, is the most common, unrecognized, distributing focus in an otherwise aseptic technique. Instruments coming out of the wound should be discarded and reboiled; not touched, wiped, or polished by the diligent, well intentioned, but inexperienced, student nurse or assistant.

b. In accidental wounds, unfortunately so common in our day of motor accidents and world wars, the devitalized contaminated tissues must be cut away and the wound thoroughly irrigated with sterile normal salt solution. The late war demonstrated this, and subsequent years have corroborated this essential principle.

c. Foreign bodies, such as heavy ligatures, sutures, and drains should be reduced to a minimum. Drains should never be used in the repair of clean wounds unless uncontrolled hemorrhagic ooze threatens vital structures by pressure of blood clot or retained blood. Foreign bodies predispose to infection in a wound which otherwise would take care of contaminating bacteria.

d. Bacteriostasis by means of chemotherapeutic measures. During the late war the use of Dakin's solution with various modifications of the Carrel technique demonstrated the more rapid healing of contaminated wounds than with ordinary dressings. Débridement of contaminated wounds was shown in the latter part of the war to be more important in obtaining primary union.

In the last 3 years a new principle of introducing into the body and interstitial fluids a bacteriostatic substance in the form of an azo dye containing a sulfonamide group has very largely revolutionized our treatment of hemolytic streptococcus infections. In the form of sulfanilamide, prontosil, and sulfapyradine, various salts of the azo dye are administered by mouth or parenterally to combat hemolytic streptococcus, pneumococcus, and colon bacillus infected wounds and as a means of preventing potentially contaminated wounds from becoming infected. These dyes act as bacteriostatic rather than bactericidal agents, giving the normal body defense mechanisms of the leucocytes, reticulo-endothelial cells, and immune bodies the upper hand in disposing of bacteria in the blood, in the tissues, or on wound surfaces before they have a chance to multiply and destroy tissue. They are especially effective in the rapidly diffusing and virulent forms of hemolytic streptococcus infections, such as streptococcus lymphangitis, cellulitis, and erysipelas.

3. *The severed tissues should be replaced and maintained in apposition to as nearly normal anatomical relations as possible.* This is relatively easy in clean incised wounds, especially those made by the surgeon in his approach to surgical lesions, but it may be difficult or impossible in lacerated or inflamed tissues. In accomplishing this apposition and maintaining it, mechanical measures of suturing and pressure have been developed and are used by the surgeon. But in applying these mechanical measures he must constantly bear in mind the following great and most important principle so often disregarded by the mechanically minded surgeon.

4. *The restoring and maintaining of nutrition of the tissues involved in the wound is important.* Devitalized tissue means necrosis and inevitably infection, which the healing process in the tissues may or may not be able to handle. This maintenance of nutrition, or avoiding of devitalization, of the tissues in and about the wound is dependent upon (a) preserving the blood supply to the tissues, as far as possible, by avoiding mass ligature of vessels and their surrounding muscle and fascia, using fine pointed, instead of blunt, hemostats, and ligatures that do not have a tensile strength more than double that of the tissues ligated; (b) reducing to a minimum the trauma caused by blunt hemostats, large needles, and heavy suture material, and the tension of tight sutures in repairing the wound; and (c) avoiding the application of pressure to the closed wound, by dressings and bandages, greater than the impaired circulation in the repaired tissues will stand.

TABLE I.—WOUND HEALING BY SUTURE MATERIAL—CLEAN CASES, 1932–1938

Year	No. of cases		Percentage of infection	
	Silk	Gut	Silk	Gut
1932	656	306	2.3	9.2
1933	526	351	3.0	8.0
1934	864	316	2.0	7.0
1935	994	423	2.7	4.0
1936	1,149	407	2.7	4.4
1937	1,296	318	1.9	4.1
1938	1,130	314	1.8	3.5
Total	6,615	2,435	2.3	5.7

5. *The patient and the repaired wound should be placed at rest.* This can be accomplished (a) by eliminating pain during and after operation. The proper selection of the anesthetic and pre-operative and postoperative sedatives is essential; (b) by supporting and immobilizing painlessly the repaired parts until fibroplasia and nutrition of the wound edges are completed; and (c) by eliminating tissue tension caused by tight sutures, muscle spasm, and distention. In many wounds tissue tension causes pain and this results in muscle spasm. In the abdomen this predisposes to pulmonary complications and wound disruption. Bowel distention in intestinal anastomosis results in tissue tension on the suture line, leakage with peritonitis, or fistula

formation. The use of the Miller-Abbott tube in intestinal resection has eliminated the use of enterostomy and has reduced the hazard of ileus more than any other known therapeutic measure.

6. *Normal tissue metabolism should be restored and maintained.* Great advances in blood chemistry have been made recently in this field of therapy by determining and maintaining (a) fluid and electrolyte balance; (b) carbohydrate metabolism; (c) proper elimination of body excretions; and (d) by preventing and correcting cardiovascular disturbances.

With these principles understood and appreciated by the surgeon in the course of his training, it is most gratifying to observe how inevitably his solicitous care develops in the closure of his wounds, and how invariably he demands finer instruments and finer sutures and ligatures in repairing tissues. Whether he uses catgut or silk is of little importance provided he has the philosophy and the solicitous interest in repairing accidental wounds or the ones he has to make in the course of his surgery. If he has these, he will develop standards and a critique that will not tolerate unnecessary tissue trauma and slovenly wound repair. He will insist upon closing his own operative incisions. He will keep careful records of his wound healing and will strive for the 99 per cent of clean wound healing, knowing that the 100 per cent is a limit approached but never actually reached.

Recently, in the Listerian Oration delivered at the meeting of the Canadian Medical Association in June of 1939, the speaker called attention to the effect of carefully observing and recording clean wound healing, with an annual reporting of the results in a clinic having an adequate bacteriological laboratory under the supervision of a surgeon trained and interested in bacteriology.

All real surgeons have been interested in wound repair. Paré, John Hunter, Lister, and Halsted were constantly studying the care of wounds, and contributed fundamentally to the permanent literature on the subject. They were zealous in the training of the young surgeon in this phase of his science and art. Certainly there is no more durable satisfaction than that of watching the development of a constructive attitude in wound healing in the resident surgeon during his apprenticeship. Inasmuch as we make wounds in our work as surgeons, we certainly should be constantly striving to repair these wounds in as ideal a manner as possible. This is a tradition unique in our profession and we should cherish it.

VITAMIN AND PROTEIN FACTORS IN PRE-OPERATIVE AND POSTOPERATIVE CARE OF THE SURGICAL PATIENT

EMILE HOLMAN, M.D., F.A.C.S., San Francisco, California

THE *Romance of the Vitamins* might well be the title of the story of those accessory food factors which Gowland Hopkins, in 1909, described as being indispensable for the maintenance of growth and life, which Funk, in 1911, called "vital amines," which McCollum, in 1914, found devoid of nitrogen and therefore designated his newly discovered unidentified dietary factor as "fat-soluble A," and which now threaten by their increasing numbers to exhaust the alphabet in such designations.

The beginning of the story dates back several centuries, when scurvy lurked menacingly and diabolically in the hold of all seafaring craft, only to have it miraculously disappear the moment land was reached and fresh food was again available. As early as 1747, James Lind showed by controlled experiments that orange or lemon juice was a specific cure.

Based on the long held conviction of physicians in the tropics that beriberi was a disturbance of nutrition, Eijkman, in 1896, presented the first scientific evidence of the existence of important accessory food factors by producing experimental polyneuritis in pigeons fed on polished rice. Stirring controversies as to whether beriberi was the result of contagion or nutritional deficiency culminated in the mass experiments of Fraser and Stanton who took 300 Javanese laborers into the jungle, divided them into two groups, feeding one group a ration containing polished rice and the other the same food except for the substitution of less refined rice. Beriberi developed in the first group after 3 months, whereupon the diets were reversed and the second group developed the disease. Of supreme importance with respect to optimum nutrition was the observation in these human guinea pigs that physical impairment occurred almost as soon as the experimental diet was inaugurated, although the classical symptoms of beriberi required a depletion period of 3 to 4 months. Since this classical experiment the vistas are ever broadening, additional vital factors are still being discovered, their chemical structures accurately formulated, and their artificial syntheses successfully accomplished. Their clinical significance in surgery is just beginning to be appreciated (36, 37, 48, 64).

During the past 11 years patients on my service at the Stanford University Hospital have been prepared for operation by several days of a high-caloric, high-vitamin diet supplemented by vitamin concentrates. Although such preparation had its stimulus in the excellent researches on vitamin A by Mellanby (26, 51) of Great Britain, subsequent experimental and clinical observations have provided adequate justification for stressing all the vitamins in such pre-operative preparation. Originally administered once or twice daily as a "vitamin cocktail" in the form of 1 ounce of codliver oil in the juice of a lemon, washed down by the juice of 2 oranges, the vitamins are now given in the form of haliver oil capsules, 2 thrice daily, supplemented by the juice of 4 oranges and 2 lemons daily and the ingestion of some form of vitamin B. Preference should be given to the concentrates of the entire vitamin B complex and not to isolated fragments limited to B_1 or B_2. In operations of election, such as thoracoplasty, cholecystectomy or hernia, such preoperative preparation is begun at home 1 and 2 weeks before admission to the hospital. In emergency procedures cevitamic acid and thiamin chloride are administered parenterally just before operation and in the immediate postoperative period. It is hoped that vitamin A will soon be available for parenteral injec-

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tion in more practical form. On the third day following operation, the vitamin concentrates are resumed by mouth and continued throughout the full convalescent period.

What are the known facts substantiating the importance of stressing the nutritional preparation of the surgical patient? Is there a definite lack of vitamins in the ordinary diet? Minot observes that "borderline states of nutritional instability are much more common than is usually appreciated. There is a wide zone between optiminal nutrition and the level at which classic symptoms of recognized dietary deficient states develop." As stated editorially in 1937 (36), the submerged half of the population, which lives on overcooked stews, doughnuts, and coffee, is probably in a chronic state of vitamin deficiency. As a test of this presumption, we recently studied the vitamin C content of the blood of patients admitted on the surgical clinic wards of Lane-Stanford Hospital in San Francisco. Despite the ready and cheap availability of fruit in this California region, a surprising number of patients showed a very low concentration of vitamin C in the blood (Table I).

In their studies on the vitamin C contained in the plasma of infants, Lanman and Ingalls segregated the groups as follows:

	Plasma ascorbic acid mgm. per 100 c.cm. blood
1. Well baby clinic	1.00
2. Ward patients—good vitamin C content in diet	0.73
3. Ward patients—poor vitamin C content in diet	0.22
4. Ward patients with frank scurvy	0.08

In his studies on the urinary excretion and blood concentration of ascorbic acid in infantile scurvy, Ingalls (40) presents the following figures:

State of vitamin C nutrition	Plasma ascorbic acid mgm. per cent
Optimum	
Saturation	2.00 to 1.00
Normal	1.00 to 0.70
Low normal	0.70 to 0.50
Suboptimum	0.50 to 0.30
Deficiency	
Asymptomatic scurvy	0.30 to 0.15
Clinical scurvy	0.15 to 0.00

On this basis our studies show that approximately 44 per cent of free clinic patients, who usually fall in the low economic group, gave evidence of being on a diet poor in

TABLE I.—SHOWING AMOUNTS OF ASCORBIC ACID PRESENT IN PATIENTS' BLOOD

Case No.	Diagnosis	Ascorbic acid mgm. per 100 c.cm. blood	Case No.	Diagnosis	Ascorbic acid mgm. per 100 c.cm. blood
1	Appendicitis	.63	35	Hernia	.14
2	Carcinoma of stomach	.38	36	Appendicitis, acute	.20
3	Peptic ulcer	.20	37	Peptic ulcer	.03
4	Cord tumor	.20	38	Polyp larynx	.40
5	Case 2	1.00	39	Brain tumor	.19
6	Case 3	.48	40	Acute appendicitis	.32
7	Empyema	.70	41	Brain tumor	.14
8	Hare lip	1.20	42	Carcinoma of the rectum	.23
9	Peptic ulcer	.70	43	Inguinal hernia	.13
10	Thrombo-angitis obliterans	.48	44	Acute appendix	.17
11	Fractured arm	.48	45	Lymphopathic venera, stricture	.14
12	Thyroidectomy	.24	46	Pilonidal sinus	.16
13	Carcinoma of rectum	.15	47	Acute appendicitis	.20
14	Abdominal fecal fistula	.36	48	Chronic appendicitis	.25
15	Cholecystitis	.38	49	Goiter	.19
16	Epilepsy	.34	50	Avitaminosis	.26
17	Carcinoma cecum	.30	51	Case 30	.39
18	Varicose ulcer, cellulitis	.27	52	Brain tumor	.22
19	Fistula in ano	.40	53	Epilepsy	.22
20	Cholelithiasis	.22	54	Case 37	.20
21	Infected third degree burn	.17	55	Case 42	.31
22	Case 12	.22	56	Case 43	.25
23	Melanosarcoma	.19	57	Leg scar for skin graft	.25
24	Infected scar	.31	58	Hemorrhoids	.31
25	Colloid goiter	.50	59	Benign breast tumor	.35
26	Muscular atrophy	.30	60	Appendiceal abscess	.22
27	Berger's disease	.30	61	Inguinal hernia	.33
28	Sequestrated zygoma	.18	62	Fistula in ano	.31
29	Cervical rib	.38	63	Cholecystitis	.14
30	Observation	.38	64	Cellulitis, hand	1.5
31	Fistula in ano, tuberculous	.32	65	Fissure in ano	.80
32	Cholecystitis, chronic	.32	66	Leucemia	.26
33	Observation	.12	67	Duodenal ulcer, perforated	.70
34	Observation	.25	68	Fistula in ano	.70
			69	Carcinoma, stomach	.40

TABLE I.—SHOWING AMOUNTS OF ASCORBIC ACID PRESENT IN PATIENTS' BLOOD—Continued

Case No.	Diagnosis	Ascorbic acid mgm. per 100 c.cm. blood	Case No.	Diagnosis	Ascorbic acid mgm. per 100 c.cm. blood
70	Excision scar	.80	73	Case 45	1.8
			74	Case 35	2.0
71	Colles' fracture	.60	75	Case 21	3.4
72	Carcinoma of breast with metastasis	.40	76	Cord tumor	1.7
			77	Cholecystitis	2.0

vitamin C and 9 out of 70 patients were on the border line of scurvy. Youmans and his associates in a study of 16 presumably normal subjects found 8 to have evidence of vitamin C deficiency.

Of 34 patients admitted to a London hospital (27), 14 showed evidence of vitamin C subnormality and most of the remainder excreted not more than the minimum standard. All those above 70 years of age showed relative deficiency. Of interest to hospital authorities, responsible for the diet of their patients, was the observation that certain patients admitted for the dietetic treatment of peptic ulceration showed no deficiency in vitamin C on admission, but 4 days of the dietetic regimen produced a deficient excretion.

Ingalls and Warren (41) in a study of 20 patients with gastric and duodenal ulcers found 18 to have low ascorbic acid values in the blood and 12 had values of 0.2 milligram ascorbic acid per cent or less, as compared with a normal range from 0.6 to 2 milligrams per cent. Eight patients of the 20 had previously had gastro-intestinal hemorrhages.

This evidence from various sources speaks for itself. To find 44 per cent of our ordinary "run-of-the-mill" patients deficient in vitamin C and 13 per cent on the verge of scurvy is a startling fact when one considers the known effects of such a deficiency upon the animal organism. Wolbach (66) describes those effects as primarily an inability to produce and maintain certain intercellular substances. The intercellular substances concerned are the collagen of all fibrous tissue structures, the matrices of bone, dentin and cartilage, and all non-epithelial cement substances including that of the vascular endothelium. The failure of the cement substance in blood vessels leads to hemorrhages as in scurvy. Degeneration of skeletal and cardiac muscle may occur in long continued partial deficiency. Large regions of bone marrow become devoid of blood-forming cells, and anemia may therefore be an important secondary effect of the lack of vitamin C.

Guinea pigs maintained on a low cevitamic acid intake develop all the features of pyorrhea alveolaris, namely, loosening and wandering of the teeth and marked rarefaction of the alveolar bone with widening of the peridental membrane (9).

Of real surgical importance are Hojer's original observations that ascorbic acid is intimately concerned with the synthesis and maintenance of the intercellular supporting materials, which provide the framework of healing. These facts formed the basis of important investigations by Lanman and Ingalls later confirmed by Taffell and Harvey. They studied the healing of wounds in guinea pigs partially depleted of their vitamin C depot, and subsequently maintained at a low level of ascorbic acid supply. They considered the nutritional state of these animals to be analagous to asymptomatic scurvy, and therefore probably analagous to 13 per cent of our clinic patients. Wound healing in these partially scorbutic animals showed inferior tensile strength, a disposition of the wounds to gape before rupturing, a livid appearance and a soft consistency of the granulation tissue. As a result, the abdominal wounds of this scorbutic group ruptured at a pressure averaging about one-third of that required to rupture the wounds of normal animals.

Pertinent clinical evidence is provided by Archer and Graham who found the cause of death to be peritonitis in 16 of 51 patients who died after operations upon the stomach at St. Bartholomew's Hospital. In 12 of these, the peritoneal infections appeared to have arisen as a bacterial leakage at the site of anastomosis, following an almost complete absence of fibrous tissue response along the suture line.

The evidence for the greater need of vitamin C under certain diseased conditions is equally startling. Abassy, Harris and Ellman (1)

state that "pulmonary tuberculosis provides the most extreme example of the increased consumption of vitamin C. The daily excretion for a standardized diet falls to about one-third the controls, and the response to three days testing dose is negligible." Martin and Heise demonstrated the existence of a hypovitaminosis due to a lack of vitamin C in a large majority of tuberculous patients, and the degree of hypovitaminosis was found to parallel the extent and activity of the tuberculous process. Greene, Steiner, and Kramer showed that generalized tuberculosis developed more rapidly in animals chronically deficient in vitamin C than in non-scorbutic animals, and that chronic vitamin C deficiency combined with a tuberculous infection causes a significant shortening of the survival period. Leichentritt gave large amounts of orange juice to tuberculous guinea pigs on normal diets and found the survival period to be twice as long as that of tuberculous animals on a normal diet alone.

Similarly, Harde, Rothstein, and Ratish found a very low rate of excretion of vitamin C in pneumonia, which indicated an increased consumption of this vitamin in this disease. Vogl applies this knowledge in his treatment of pneumonias by large doses of vitamin C. As soon as pneumonia is diagnosed the patient receives 200 milligrams of ascorbic acid subcutaneously, followed by daily doses of from 200 to 500 milligrams, depending on the severity of the disease. Pulmonary abscess, chronic pneumonia, or carnification never occurred in cases treated in this manner.

In a study of 17 active cases of osteomyelitis (17 semi-cured patients, 16 healed, and 10 controls), Abassy, Harris, and Hill (2) found a diminished rate of excretion of vitamin C in the urine and a lowered response to test doses of vitamin C, indicative of an apparently increased usage of this vitamin during the infective process, greatest in the active cases, intermediate in the semi-cured, and normal in the healed.

The frequent occurrence of vitamin C deficiency suggests that other vitamins may be equally deficient. Jeans and Zentmire, using the ability to adapt to the dark as a test for detecting vitamin A adequacy, found that 26 per cent of a rural group and 53 per cent of a village group of Iowa children presented evidence of vitamin A deficiency.

Jeghers in a study of a group of medical students, who presumably should be on fairly adequate diets, found that 35 per cent were deficient in vitamin A as determined by photometric tests, and 12 per cent had clinical manifestations of the deficiency. The chief manifestations of such deficiency were night blindness, photophobia, dry skin, dry conjunctival blepharitis, and follicular hyperkeratosis. Evidence was also obtained from this study that infections were more numerous and severe among the deficient students.

Thirty-eight patients entering the Stanford-Lane Clinic for medical and surgical care were studied by the Hecht apparatus for dark adaptation, this being considered a moderately accurate indication of the degree of vitamin A sufficiency or deficiency. To our astonishment, 10 patients, or 26 per cent, showed a marked deficiency in vitamin A; 9, or 24 per cent, showed a mild deficiency; 10, or 26 per cent, were normal; and 9, or 24 per cent, showed a supersufficiency of vitamin A in their diets. In other words, one-half of the ordinary "run of the mill" patients who present themselves to a free clinic for treatment are deficient in their intake of vitamin A. Eight patients, or 20 per cent, were night blind.

The effect of such vitamin A deficiency is most pronounced on the epithelial structures (67). These undergo an atrophy, followed by a reparative proliferation of the basal cells, replacing the normal columnar cells by a stratified keratinizing epithelium. This keratinizing metaplasia involves (1) the salivary glands, including the submaxillary, parotid, and all accessory glands of the tongue, buccal cavity, and pharynx, (2) the respiratory tract, including the nares, maxillary sinuses, trachea, and bronchi, (3) the genito-urinary tract, including the renal pelves, ureters, bladder, epididymis, prostate, seminal vesicles, uterus, and vulva, and (4) the eyes and peri-ocular glands. This metaplasia results in the accumulation of keratinized cells in glands and their ducts, and in organs such as the lungs, and leads to the occlusion of bronchi, the

formation and filling up of bronchiectatic cavities with keratinized cells, and atelectasis. These changes are presumably responsible for the spontaneous infections that occur so frequently in the mouth, the salivary glands, and the genito-urinary tract of animals on vitamin A free diets (26, 39).

The importance of normally functioning epithelial surfaces in surgical patients needs no elaboration. Healthy epithelial tissue is undoubtedly a more efficient barrier to infection than epithelium whose structure has been altered by a vitamin deficiency. Parotitis, purulent bronchitis, pneumonia, and urinary infections are postoperative bugbears. To operate on patients deficient in vitamin A is inviting the development of such complications. According to Wolbach "the early effect of the deficiency on the respiratory mucosa is a satisfactory explanation of the frequency, severity and persistence of the pneumonia that has been responsible in most instances for the death of infants deficient in vitamin A."

That vitamin A deficiency may occur through faulty absorption due to hepatic or gastro-intestinal disease is suggested in isolated case reports. Among these may be mentioned night blindness in a man with a gastrocolic fistula following a gastric operation (65), xerophthalmia in a patient with hepatic cirrhosis (55), and in a patient with hepatic cirrhosis secondary to carcinoma of the liver (6). The association of chronic jaundice, night blindness, and xerophthalmia (3), though still unexplained, has led to the assumption that bile is necessary for the proper absorption of vitamin A. In experimental biliary fistulas, Greaves and Schmidt (24) found that vitamin A was absorbed only if supplied orally with bile salts. On present knowledge then, when giving vitamin A to patients with jaundice, bile salts should also be administered. The parenteral administration of vitamin A is occasionally indicated. Finkelstone et al. have administered a high concentrate (100,000 vitamin A units and 12,500 vitamin D units per cubic centimeter) to pregnant women in dosages of 1 cubic centimeter every fortnight with safety. Chu and Lin studied 3 infants and 6 adolescents who showed various degrees of xerophthalmia due to vitamin A deficiency with an associated diarrhea. An improvement of the eye condition was noted within 2 days after the intramuscular injection of avoleum, a vitamin A concentrate containing 20,000 units per gram. It was injected in divided doses of 1 and 2 cubic centimeters in different areas. The beneficial effect of a single dose of vitamin A concentrate given parenterally may last as long as 2 months.

Vitamin B deficiency is not so accurately determined, but certain qualities of the vitamin make it important in the surgical patient. Vitamin B has a stimulating action on the growth of plants. In periods of active growth there is a corresponding increase in requirements of vitamin B, i.e., infants and growing children require a much larger daily supply than adults. The polyneuritis, the weakened cardiac musculature, the atonic and weakened gastro-intestinal musculature with its associated anorexia, intestinal atony, and constipation are the more common results of vitamin B deficiency (15). Their avoidance in the surgical patient is vital. It has been stated that these symptoms of vitamin B deficiency remain latent at times and appear only with the onset of some intercurrent infection, during pregnancy, after a surgical operation, or other event which requires an increased bodily metabolism. It is significant that in the experiment on 300 Javanese, general physical impairment occurred long before the symptoms of beriberi appeared.

According to Cowgill the vitamin B requirements in man bear a direct relationship to metabolism and are increased in diuresis and diarrhea. Inasmuch as there is a very limited capacity for storage of vitamin B in human tissues, Frazier and Ravdin argued that the vitamin B requirement should be increased in hyperthyroidism. Accordingly they administered to a group of hyperthyroid patients 10 milligrams of crystalline vitamin B_1 every other day and 10 grams of brewer's yeast daily by mouth, with a demonstrable improvement in their nutritional state, a greater fall in pulse rate, and a shorter pre-operative period of preparation for the very ill patient.

Another mode of action of vitamin B may be related to an observation by Manville and

Grondahl, who found that the regeneration of red cells is possible only if yeast or some factor in yeast is included in the diet. Erythrogenesis in rats on a basal diet excluding the vitamin-B-maturation factor stopped at the megaloblastic stage. Some factor in yeast was necessary to carry the megaloblast to the normoblastic stage. The importance of this observation in the restoration of the normal blood volume immediately following severe blood loss at operation cannot be overestimated.

Of major importance in the preparation of the jaundiced patient for operation are 2 recently discovered facts: first, that the bleeding, which so easily and so frequently occurs in these patients, is due to a low level of prothrombin in the blood, and secondly, that for the formation of this prothrombin, presumably in the liver, a specific food factor designated as vitamin K is indispensable (16, 17). The vitamin is found in alfalfa, spinach, and kale, or it may even be synthesized in the lower intestine through bacterial activity. As it is a fat soluble substance, bile is necessary for its absorption. In the patient with jaundice, with a biliary fistula, with an intestinal fistula, or with prolonged duodenal syphonage as in intestinal obstruction, bile does not reach the lower intestine, vitamin K is not absorbed, the prothrombin cannot, therefore, be formed, it falls to low levels in the blood, and fatal bleeding may occur either spontaneously or following the trauma of operation (60).

In the pre-operative preparation of the jaundiced patient, not only is the administration of vitamin K imperative, but also the administration of bile salts (11). The quantity administered depends largely upon the level of the prothrombin in the blood. This is determined according to the method of Quick (57, 58). Patients with a normal prothrombin clotting time are treated prophylactically with 2000 to 6000 units of vitamin K, together with 1 to 4 grams of bile salts daily. Patients with a prolonged prothrombin clotting time, without bleeding, and those actively bleeding, receive correspondingly larger doses.

If the liver has been injured by poisons, infections, or new growth, the level of prothrombin in the blood also falls. In such instances there is, however, no vitamin deficiency but a destruction of the site where prothrombin is formed, and vitamin K will not correct the condition. The administration of this vitamin is equally useless in the bleeding of hemophilia, thrombopenia, or aplastic anemia. But the hemorrhage that occurs in jaundice, in intestinal obstruction from any cause, in intestinal or biliary fistulas, in prolonged diarrhea, or in ulcerative colitis, may be controlled by the administration of this vitamin, together with bile salts.

Additional evidence of the importance of the pre-operative nutritional preparation of the surgical patient is presented in the experimental observations of Thompson, Ravdin and Frank. In 8 out of 11 dogs operated upon in a hypoproteinemic state, the wound failed to heal and a disruption occurred. As early as 1919 Clark showed an improved repair in dogs on a high protein diet, and Harvey and Howes showed an accelerated fibroplastic proliferation on a similar high protein diet. Ravdin states that a liver high in fat and low in protein is maximally susceptible to injury. A liver low in fat and high in available protein is maximally resistant to such injury. These observations give added support to our practice of giving surgical patients a balanced diet of high caloric value in the pre- and postoperative periods. In appropriate cases, Thompson, et al., suggest restoring the serum protein to normal levels by the intravenous infusion of lyophile plasma.

As these various studies suggest, our knowledge concerning nutrition, though rapidly and phenomenally progressing, is still in its infancy. Well may we ask, how do the vitamins act? What is their fate after their ingestion? It is probable that they are not specific in their effects, although many attempts have been made to attach the attribute "anti-infective" to vitamin A. As the exact chemical structure of the vitamins unfolds, it appears that it approximates in some degree the chemical structure of the endocrine hormones. The hexuronic acid isolated by Szent Gyorgi from the adrenal cortex in considerable quantity proved to be identical in structure with vitamin C. Freeman and Glass

found a definite relationship between vitamin C level of the blood plasma before death, and the incidence of central autolysis of the adrenal glands at autopsy. If the reduced ascorbic acid value was above 0.70 milligram per cent, no central cavities were found in the adrenal glands, while on the other hand, if the value was below 0.70 milligram per cent, central cavities were invariably present. Harris, Passmore and Pagel found that guinea pigs, suffering from an acute infection with pasturella pseudotuberculosis, showed a considerable diminution in the amount of vitamin C present in their suprarenal glands as compared with controls which had received the same amount of vitamin C. The vitamin C in the liver, on the other hand, was not significantly affected. Normally the pituitary and adrenal glands are said to contain vitamin C in greater abundance per gram of gland substance than any other known substances. The liver has been credited with being a storage depot for vitamin A. In cirrhosis, Moore has found vitamin A in very low concentration.

In view of this evidence, are we not justified in assuming that in order that the liver and the all important endocrine organs may function normally, they must be properly nourished through an adequate supply of vitamins? With these organs functioning in optimum efficiency, due to optimum nutrition, one may logically infer that the patient is better able to meet the ordeal of operation, to heal the disrupted tissues more kindly, and to avoid the distressing complications of infection and delayed repair.

With the additional convincing evidence that many patients live in a chronic state of vitamin deficiency, should we not insist that whenever possible a few days be assigned before operation to the necessary nutritional preparation of the surgical patient? "Ideally, every patient should be hospitalized one or even two weeks before operation with the avowed intention of improving general nutrition and of restoring the depleted store of vitamins" (36).

In a study of the vitamin C content of human tissues, Yavorsky, et al., found a consistently diminished content in all tissues studied: adrenal, brain, pancreas, liver, spleen, kidney, lung, heart, and thymus, in those patients from 46 to 77 years of age as compared to the patients from one to 46 years of age. This suggests that the older patients require a longer period of preparation by high vitamin intake than the younger patients. Orr's observations indicate further that patients from low economic levels show correspondingly increased frequency of vitamin deficiencies.

Fortunately, the effects of vitamin lack are corrected quite promptly. Reparative changes in the metaplastic epithelium begin as early as the fifth day following the ingestion of suitable amounts of vitamin A. A low ascorbic acid content of the blood is corrected within 3 to 5 days after adequate intake. Even a few days, therefore, spent in nutritional preparation of the patient should reduce the operative hazard and diminish the length of convalescence. There is little justification for the almost universal practice of admitting the candidate for an elective operation on one day and operating upon him the next. The ordeal of operation with its attendant risks should, whenever possible, be undertaken only in patients in a state of optimum nutrition.

SUMMARY

1. Seventy patients, from low economic levels, admitted to the Stanford-Lane clinic wards for operation were studied with respect to the vitamin C content of their blood. In 44 per cent of these patients, values of 0.15 to 0.30 milligram per 100 cubic centimeter of blood were found, indicative of a low vitamin C intake. In 9 patients, values fell below 0.15 milligram per cent, indicating they were on the verge of clinical scurvy.

2. This evidence of deficiency in vitamin C is of extreme importance in surgical patients, since ascorbic acid or vitamin C is intimately concerned with the synthesis and maintenance of the intercellular supporting materials which provide the framework of healing. Experimental observations by Lanman and Ingalls showed that abdominal wounds of scorbutic animals ruptured at a pressure one-third that required to rupture the wounds of normal animals.

3. Thirty-eight patients entering Stanford-Lane Clinic for surgical and medical care were studied by means of the Hecht adaptometer. Ten patients, or 26 per cent, showed a marked deficiency in vitamin A; 9 showed a mild deficiency; 10 were normal; and 9 showed a supersufficiency of vitamin A.

4. Observations by Jeans, Zentmire, and Jeghers showed that 24 to 36 per cent of the ordinary population were deficient in vitamin A.

5. Since the effect of vitamin A is to produce metaplastic changes in epithelial structures, a deficiency in this vitamin is of real importance in patients who, following operation, are threatened with infections of such epithelial structures as the salivary glands, the bronchi, the lungs, the gastro-intestinal canal, and the genito-urinary system. Animals on diets deficient in vitamin A develop abscesses and infections in these regions.

6. Experimental observations by Thompson and Ravdin indicate that animals on a low protein diet show impaired healing and disruption of wounds in 72 per cent. Howes and Harvey found an acceleration of fibroplastic proliferation in animals on a high protein diet.

7. These observations indicate that surgical patients should, whenever possible, be prepared for operation by several days of optimum nutrition, including a well-balanced diet of high protein intake, of high caloric value, and of high vitamin content. This period of preparation should begin at home 10 to 14 days before operation.

8. This preparation should also include vitamin concentrates for 5 to 7 days before operation: 2 haliver oil capsules, thrice daily; 3 B concentrate tablets, thrice daily; juice of 4 oranges and 2 lemons daily.

9. Patients with obstructive jaundice, with biliary or intestinal fistulas, with intestinal obstruction, ulcerative colitis, or persistent diarrhea, may show a prolonged prothrombin clotting time due to a low level of prothrombin in the blood, secondary to absence or faulty absorption of vitamin K. Before operation as a prophylactic measure, or, if and when bleeding occurs, such patients should receive massive doses of vitamin K and of bile salts. The latter are indispensable in the absorption of the vitamin.

10. In emergency operations, the parenteral administration of vitamins A, B, C, and in the jaundiced patient, vitamin K, is indicated.

11. Following operation, optimum nutrition should again be instituted through a well balanced, high caloric, high vitamin diet, supplemented by vitamin concentrates throughout the full convalescent period.

12. The ordeal of operation with its attendant hazards should be undertaken, whenever possible, only in patients in a state of optimum nutrition. For the past 11 years, patients admitted to the Stanford-Lane clinic wards under my control have been prepared for operation by a high caloric, high vitamin diet, supplemented by vitamin concentrates.

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RE-ESTABLISHMENT OF THE GASTRO-INTESTINAL PASSAGE AFTER GASTRIC RESECTION

Professor Doctor EUGENE PÓLYA, Budapest, Hungary

THE year 1938 marked the sixtieth anniversary of gastric resection. It was on April 9, 1878, that Péan, the famous surgeon of Paris, performed the first "gastrectomy." The idea was much older, however, for it seems that it was in the town of Philadelphia that the first experiments with resection of the pylorus of dogs and rabbits were made. At least, so says D. C. Th. Merrem, whose treatise[1] of 1810 is generally quoted as first propagating the idea of pylorectomy. A hundred years ago Dieffenbach, the greatest surgeon of his time, wrote: "The removal of gastric cancer is a dream of Merrem!"

There elapsed less than 40 years before the dream came true. After Péan, first Rydgier and later Billroth performed gastric resection, and this operation, done in January, 1881, was successful and the patient recovered. The technique used in these first three gastric resections was the same: the adequately narrowed stump of the stomach was united with the duodenum. This method is called the Billroth I operation.

In 1885 Billroth operated upon a patient in whom he found a large cancer of the stomach. The patient was so very feeble that, in Billroth's judgment, it would be impossible for him to survive extirpation of the tumor. Therefore Billroth made a gastro-enterostomy. The patient withstood this operation so well that Billroth decided he could withstand removal of the tumor as well. He therefore extirpated the tumor and closed the lines of resection of the stomach and duodenum. Thus the first Billroth II operation was accomplished.

Billroth thought that this "atypical" operation, the "combination of a Woelfler's gastro-enterostomy with resection of the stomach" as they then called it, would be suitable in cases in which the stumps of the stomach and the duodenum could not be easily brought together after the removal of a cancer. But it soon became apparent that the Billroth II operation was not only easier but also generally much safer than the Billroth I operation, and so the Billroth I operation was gradually abandoned, the majority of the surgeons showing preference for the Billroth II technique.

If the cancer is very large, however, after its removal the stump of the stomach may be so small that even the Billroth II technique may present some insurmountable difficulties. If one would occlude the small stomach stump as required by this operation, it would be so reduced in size that there would be no place for the gastro-enterostomy. Therefore, in such cases one must refrain from closing the stomach stump but instead implant the whole of it into the jejunum. This is the essential feature of the method to which I have had the honor to call attention.[2] It originated as a

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[1] Merrem, Daniel Carl Theodore. Animadversiones quaendam chirurgiae experimentis in animalibus factis illustratae. Quoted by Gussenbauer and Winiwarter in Arch. f. klin. Chir., 1875, 19: 308.

[2] I was not the only one nor the first who got into difficulties and found my way out by inventing this method, but I realized at least its great practical value and saw at once that it was not only a method of necessity, but the method of choice in the majority of cases and, therefore, saw to it that it should have due publicity because this was absolutely wanting. The method was quite unknown, not only to myself, but to all my colleagues with whom I had the opportunity to discuss it, and I vainly looked for descriptions of it in the textbooks and journals which were accessible to me.

I demonstrated my first patient operated upon with this method in October, 1910, before the surgical society of Budapest and spoke of this operation at the 1911 Congress of the German Surgical Society in Berlin (Verhandl. d. deutsch. Gesellsch. f. Chir., 1911, 1: 200) and when I saw that no one there knew of anything similar, I decided to publish a description of the technique, which appeared in the Zentralblatt fuer Chirurgie, 1911, Nr. 26. A few weeks later Wilms, then director of the surgical clinic of the University of Heidelberg, wrote an article in the Zentralblatt fuer Chirurgie, 1911, Nr. 32., in which he stated that a few months previously, even before reading my report, he had used a method similar to mine but with certain differences. In the Zentralbl. fuer Chirurgie of 1911, Nr. 42. Reichel claimed priority because he had mentioned at the 1908 Congress of the German Surgical Society in discussing a paper of Moszkovicz on aseptic intestinal operations (Ueber aseptische Darmoperationen) that he had performed 3 operations of the kind described by me. At the same time Bergmann, of Riga, sent to me a reprint of an article (St. Petersburger medizinische Wochenschrift, 1909, Nr. 52) in which he reported on 2 cases operated upon in the same manner. He did not know of Reichel's article nor did Wilms, nor did I, nor did anybody else to whom

necessary means to an end, but it proved to have some advantages over the Billroth II method, the chief of which is the saving of time by omitting the closure of the stomach stump. And so as the Billroth I method was abandoned for Billroth II technique because the latter was simpler and easier, the Billroth II operation likewise was willingly replaced by another method which seemed still simpler and easier.

Simplicity and easiness of performance, especially if the method is time saving, are certainly very important points in every operation, and not only the surgeon but also the patient who has to undergo the operation is thus benefited. Other points must also be considered, however, and one must thoroughly investigate the merits and faults of the different operative methods before he is able to decide which is the best—and often if one is just, he arrives at the conclusion that one cannot draw any general conclusion, for one method is best for a certain group of cases and another for other cases.

RE-ESTABLISHMENT OF GASTRO-INTESTINAL CONTINUITY

The manner of re-establishing gastro-intestinal continuity after gastric resection is certainly the most characteristic feature of the method employed for it and it is certainly a most important point in technique. It is by no means, however, a purely technical problem, nor should the technical side of the question be considered as the most important one.

The first thing to be remembered is the welfare of the patient which implies perfection and durability as well as safety of the cure, or at least something which is as near to these requirements as possible. The immediate safety of operation is purely a necessary preliminary, a *conditio sine qua non* for the two others, but one should always strive to secure with an equal or eventually higher degree of safety a better end-result. Also it is of advantage if one is familiar with more than one method so that he may choose the most suitable technique for the case at hand and what is still more important—select one suitable in an atypical case.

And, therefore, I think it is not superfluous to glance over the many possible methods for re-establishing the gastro-intestinal passage after resection and at the same time to revise the terminology, choosing a term which will express all, or at least all the more remarkable, characteristics of the method. Narath suggested a nomenclature to designate resections with gastrojejunostomies, but it was not complete, and in some respects not quite satisfactory. The prominent features of the different methods used for restoring gastro-intestinal continuity depend chiefly upon:

1. The form of anastomosis, whether end-to-end, terminoterminal; end-to-side, latero-terminal; or side-to-side, laterolateral.

2. The part of the intestine used for the connection with the stomach stump whether the duodenum or jejunum. The method then should be named gastroduodenostomy (duodeno-gastrostomy) or gastrojejunostomy (jejunogastrostomy). Since with end-to-side anastomoses one can implant the end of the stomach stump into the side of the intestine or else the intestine into the side of the stomach stump, one may mention first the organ which is implanted in the other.

3. The special points which vary with the various kinds of anastomosis. With end-to-side anastomoses, for instance, when the stomach stump is implanted into the side of the intestine this may be implanted narrowed or unnarrowed, and one may narrow the stomach stump by occluding the part which is in the vicinity of the lesser curvature or that part which lies at the greater curvature.

I had spoken before. The great surprise, however, came in 1916, when Narath published an article in the Deutsche Zeitschrift fuer Chirurgie, Vol. 136, which showed that von Hacker had advocated the idea of connecting the opening of the stump of the stomach directly with the jejunum and that it was Kroenlein, in 1888, who first performed such an operation (antecolic Fig. 8, a) and that since then many surgeons including Eiselsberg (Fig. 8, b) Mikulicz, Doyen, Graser (Fig. 8, c) Hofmeister, Delagenière, Sasse, and others published reports of cases in which this principle was followed with various alterations in technique (antecolic, retrocolic, narrowed and unnarrowed stomach stump). These were presented usually in casuistical publications and in demonstrations before medical societies which generally do not awake public interest. Thus it happened that not one of the surgeons, who did the operation, knew of the others who had been doing it and most of those who were doing it looked upon it as a method of exceptional value, when necessity demanded, but not as a measure of great general practical value.

The great majority of surgeons, however, did not know of the method at all until I called it to the attention of the surgical world, and especially to the attention of William Mayo who saw in it the operation of the future and whose endorsement helped to make it one most widely adopted.

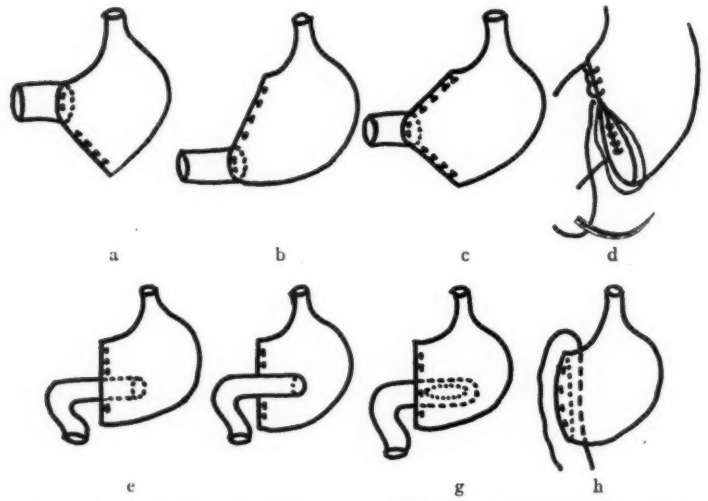


Fig. 1. Gastroduodenal anastomoses. a, End-to-end gastroduodenostomy, with narrowing of the stomach stump at the greater curvature (Gussenbauer and Winiwarter, Rydygier); b, end-to-end gastroduodenostomy with narrowing of the stomach stump at the lesser curvature (typical Billroth I); c, end-to-end gastroduodenostomy, with narrowing on both curvatures; d, method of J. Shelton Horsley; e, posterior end-to-side duodenogastrostomy (Kocher); f, anterior end-to-side duodenogastrostomy (modified Kocher); g, side-to-side duodenogastrostomy (Ito and Soyesima); h, end-to-side gastroduodenostomy (Finney, Harberer).

If the jejunum is used for the anastomosis with the stomach, there will be differences corresponding to the position of the anastomosing loop to the transverse colon and with the presence or absence of entero-entero-anastomosis and its form: side-to-side (Braun) or Y-shaped (Roux). If side-to-side anastomoses are made there will also be differences depending upon the part of the stomach used for the anastomosis. These peculiarities should be expressed by appropriate adjectives.

Anastomoses of the stomach with the duodenum (*Fig. 1*) are: (a) end-to-end gastroduodenostomy, the Billroth I method; (b) end-to-side gastroduodenostomy as advised by Finney, Haberer; (c) posterior end-to-side duodenogastrostomy, the Kocher operation, implantation of the duodenal stump into the posterior wall of the stomach; (d) anterior end-to-side duodenogastrostomy, a modification of the former operation—implantation of the duodenal stump into the anterior wall of the stomach; (e) side-to-side gastroduodenostomy as suggested by Ito and Soyesima, in which the stump of the duodenum and stomach are both closed, and the anastomosis is made between the anterior wall of the duodenum and the posterior wall of the stomach.

Anastomoses of the stomach with the jejunum are: (a) End-to-end gastrojejunostomy necessarily combined with end-to-side jejunojejunal-anastomosis (Y-shaped). It may be antecolic (Rydygier) or retrocolic (Moszkovicz) (Fig. 2, a and b). (b) End-to-side anastomoses are to be divided into two groups; first, implantation of the stomach stump into the jejunum and second implantation of the aboral stump of the transversely cut jejunum into the stomach.

End-to-side gastrojejunostomy may be done in several ways: (a) Depending upon the relation of the jejunum used for the anastomosis to the transverse colon it may be antecolic (Fig. 3) or retrocolic (Fig. 4). (b) It may be done without and with narrowing of the stomach stump (total and partial) and the narrowing may be done in the neighborhood of the lesser or the greater curvature—partial

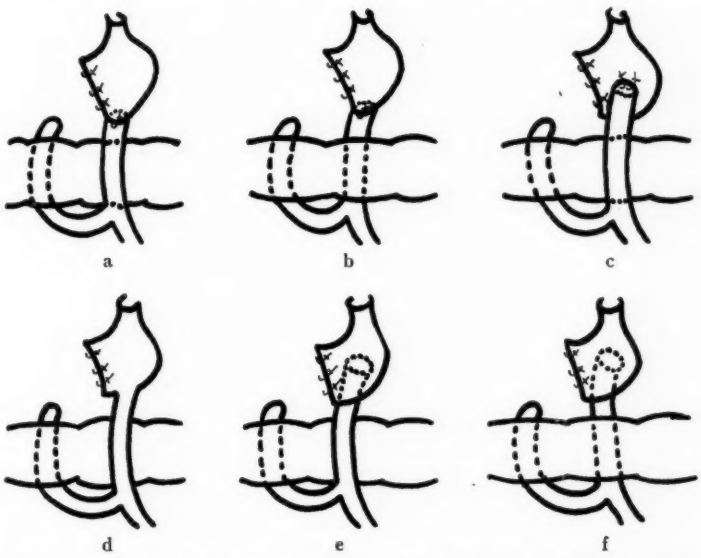


Fig. 2. a, Antecolic end-to-end gastrojejunostomy (Rydygier II); b, retrocolic end-to-end gastrojejunostomy (Moszkovicz); c, antecolic anterior end-to-side jejunogastrostomy; d, antecolic inferior end-to-side jejunogastrostomy; e, antecolic posterior end-to-side jejunogastrostomy; f, retrocolic posterior end-to-side jejunogastrostomy.

inferior and superior, according to the site of the opening. (c) It can be performed without and with lateral entero-entero-anastomosis. In other words there are altogether 12 possibilities in this group alone. The antecolic total end-to-side gastrojejunostomy is the Kroenlein-Balfour operation; the antecolic superior partial end-to-side gastrojejunostomy, is the modification by Mayo, and occludes the inferior part of the stomach stump and leaves it open in the vicinity of the lesser curvature.

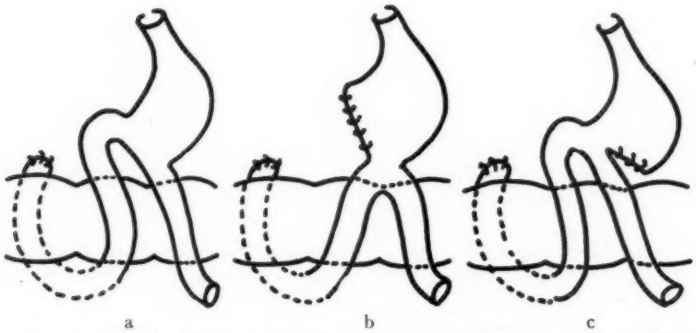
End-to-side jejunogastrostomies (Figs. 2, 3–6) are combined necessarily, as the end-to-end gastrojejunostomies described under section (a), with Y-shaped end-to-side jejunojejunostomies. The jejunum may lie before and behind the transverse colon and may be implanted into the anterior or posterior wall of the stomach or its greater curvature. There are, therefore, 6 possibilities in this group (antecolic anterior, posterior and inferior and retrocolic anterior, posterior and inferior).

Side-to-side gastrojejunostomies (Fig. 5). In this group the anastomotic loop may lie before or behind the transverse colon and communicate with the anterior or posterior wall of the stomach or its greater curvature and it may be combined or not with side-to-side entero-entero-anastomosis; that means that there are 12 possibilities in this group. Gastric resection with antecolic anterior side-to-side gastrojejunostomy would be the correct name for the classical Billroth II operation.

To sum up we find that there are 37 typical methods available for the re-establishment of gastro-intestinal continuity after resection.

If in addition to performing an end-to-side, or a side-to-side gastrojejunostomy, a Y-shaped entero-entero-anastomosis is done, that would increase the methods by 12. To carry out such steps in most cases would only increase the difficulties; in some situations, however, such procedures would be found helpful.

When speaking of gastric resection, partial removal of the stomach with the pylorus and antrum, or at least with the whole mucosa of the pylorus and antrum, is meant. Hence the methods aiming at the re-establishment of



a b c

Fig. 3. Antecolic end-to-side gastrojejunostomies. a, Total (Kroenlein, Balfour); b, partial inferior (Eiselsberg, Mikulicz); c, partial superior (W. Mayo).

gastric or gastro-intestinal continuity after other mutilating gastric operations (removal of the cardia, total gastrectomy, resection of the lesser curvature, sleeve-resection, various excisions) are not considered. The number of the aforementioned methods may be increased considerably by special technique or by peculiar circumstances.

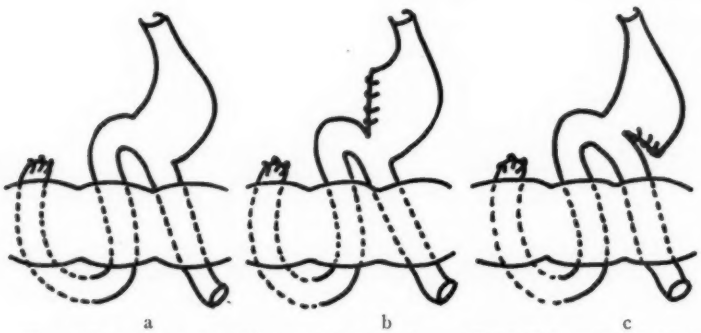
Concerning solutions of these problems, two Hungarian examples may be mentioned:

First, Hueltl constructed a special clamp for closing the stomach stump with tiny clips of aluminum-silver wire; this "stomach sewing-machine" was simplified and modified in several ways by Petz and Donati, etc. Its use was advised in the classical Billroth II, but it may be used also in partial inferior end-to-side gastrojejunostomy. Verebély cuts away the inferior corner of the closed stomach stump and connects this opening with one made in the jejunum (Fig. 9, a, b, c).

Second, in the presence of jejunal ulcer after gastro-enterostomy combined with side-to-side entero-entero-anastomosis Fischer advised connecting the stomach stump with the two limbs of the jejunal loop used for the gastro-enterostomy, which are found generally adherent to each other (Fig. 9, d, c). It seems much easier and better to close the two stumps of the amputated jejunal loop and aborally from them to make an end-to-side gastrojejunostomy (Fig. 9, h, i).

NARROWING AND LENGTHENING THE STOMACH STUMP

Let me mention here some methods devised for narrowing the stomach stump. The methods were first advised to adjust the discrepancy



a b c

Fig. 4. Retrocolic end-to-side gastrojejunostomies. a, Total (Delagenière, Reichel, Bergmann, Pólya); b, partial inferior (Graser, Hofmeister, Wilms, Finsterer); c, partial superior (Goetze).

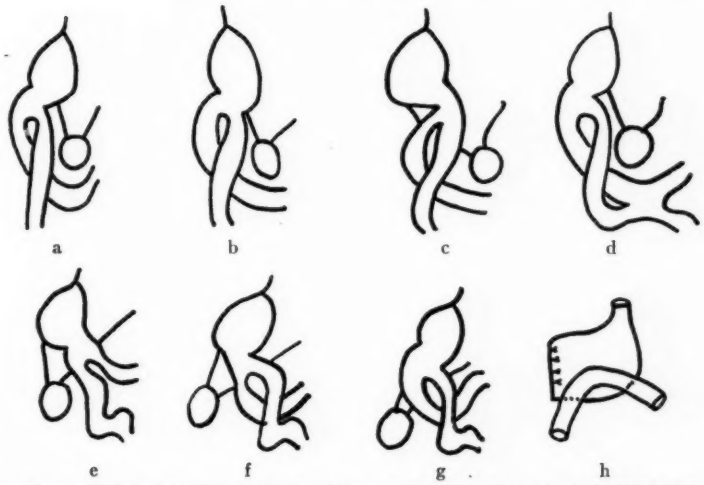


Fig. 5. Side-to-side gastrojejunostomies. a, Antecolic anterior (typical Billroth II); b, antecolic inferior; c, antecolic posterior; d, antecolic anterior with side-to-side entero-anastomosis; e, retrocolic posterior; f, retrocolic inferior; g, retrocolic anterior; h, typical Billroth II.

between the lumina of the gastric and duodenal stumps before making an end-to-end gastroduodenostomy. Gussenbauer and Winiwarter, in 1874, in their experiments with pylorectomy on dogs cut out a wedge of the greater curvature in order to equalize the openings which were to be united (Fig. 1, a). This step was followed by Rydygier and by Billroth in his first 2 gastric resections. In the classical Billroth I operation the narrowing was done on the lesser curvature (Fig. 1, b). Some surgeons narrowed both curvatures (Fig. 1, c) and the advice to narrow the resection-line on the great curvature also returned later. For example J. Shelton Horsley of Richmond, Virginia, advised the alinement of stomach and duodenum at the lesser curvature and the tucking in of the superfluous lower border of the gastric stump (Fig. 1, d). Haberer lessened the lumen of the stomach stump by means of a row of interrupted submucous catgut sutures. In this way the narrowing of the stomach stump is distributed along the whole circumference. The following 2 rows of suture help to complete this and at the end of the operation the duodenum is invaginated into the stomach and fits into it "as the stalk of the mushroom fits into its pileus" (Orator).

But it was generally along the lesser curvature that the narrowing of the stomach stump was done when the classical Billroth I operation was performed, and even in the modifications of the Billroth I the same general scheme was followed. Goepel with his "Einmanschettierungsverfahren" attempted to insure the suture by forming of the stomach a cuff-like flap consisting of the gastric serosa and muscularis, which covered the suture uniting the gastric and duodenal mucosa as a cuff (*Manschette*) covers the wrist. (Fig. 6, c.)

Shoemaker was the first, at least as far as I was able to learn, who showed the importance of lengthening the stomach stump (1910)

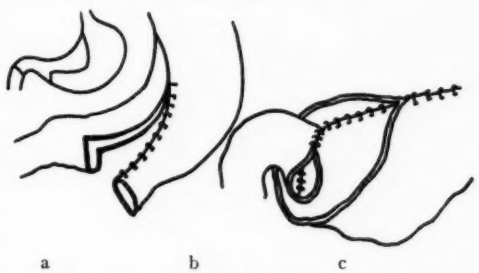


Fig. 6. a, Line of incision; b, Kirschner's *Schlauchresection;* c, Goepel's *Einmanschettierungsverfahren.*

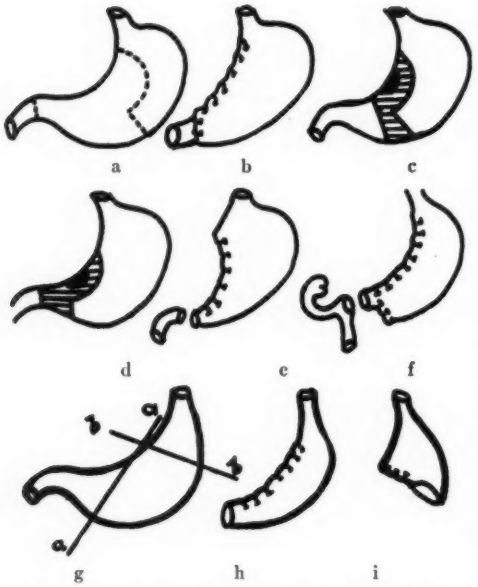


Fig. 7. a, b. Shoemaker's operation. a, Lines of incision; b, end-to-end gastroduodenostomy; c, Schmieden's *Treppen* resection, intragastric, leaving antrum; d, the same removing antrum and pylorus; e, finished by end-to-end gastroduodenostomy; f, finished by partial superior end-to-side gastrojejunostomy; g, directions for the incision of stomach for lengthening, *a-a*, or shortening, *b-b*, the stump of stomach; h, lengthened stomach stump (this is the one I always use); i, shortened stomach stump.

by giving to it the shape of a tube. He calls it *Schlauch* or hose. This was done earlier also, first by Graser, as far as I can find, but its importance at least was not emphasized. The technique used by Shoemaker, which requires special clamps, is a little awkward, but the kind of incision he used for shaping the stomach stump (Fig. 7, 2) was adopted by Schmieden in his *Treppenresection* (Fig. 7, d —stair-shaped resection) and by Kirschner for his *Schlauchresection* (Fig. 6, a—hose-like resection). Both used this kind of stomach stump not only for gastroduodenostomy but also for end-to-side gastrojejunostomy. The method of Schmieden is founded not only on technical but also on pathological and physiological considerations. His technique aims to build up a new lesser curvature (*Magenstrasse*, Waldeyer) which has some physiological importance; it eliminates the old lesser curvature which plays a great part in the pathogenesis of ulcer (Aschoff). But one is able to lengthen the stomach stump in a much simpler way (Fig. 7, g, *a-a*) and to make reliable clamping possible and thus insure asepsis.

Also with end-to-side gastrojejunostomies, in spite of the fact that before the publication of my article in 1911 such operations were done only very seldom and in quite exceptional cases and although the technique was unknown to the majority of surgeons, the fact remains that the step of narrowing the stomach stump is a very old one. It would seem that it was first done by Eiselsberg[1] and Doyen.[2]

The most important communication is that of Graser in 1906, not only because he seems to have been the first who performed retrocolic operations of this kind, but also because he mentions that the stomach stump, which he implanted into the jejunum, was very similar to the intestine, and his illustration shows also the "bowel-like stomach" (*darmaehnlicher Magen*). The lengthening of the stomach stump is very important in the facility with which the re-establishment of the gastro-intestinal continuity after gastric resection is secured (Fig. 8, c).

SELECTION OF METHOD

Is there a method among all those mentioned which is preferable in all cases or shall we select a certain method for a given case, and what are the criteria on which the merits of the different methods should be judged?

It is very difficult to answer these questions. Perhaps it would be better to show the dangers connected with the different types of operation for the re-establishment of gastro-intestinal continuity. The dangers arise chiefly from three factors: (a) The difference in size of the openings which are to be united by suture; (b) Undue tension on the structures which have to be brought together; and (c) disturbances in the passage of gastric contents immediately or some time after operation.

As to the difference in size of the gastric and duodenal stumps, this factor was responsible for the greatest difficulties encountered

[1] Resektion mit Gastroenterostomie, 1889, Fig. 8, b.
[2] Pylorectomie combinée avec la gastroenterostomie a raquette, 1892.

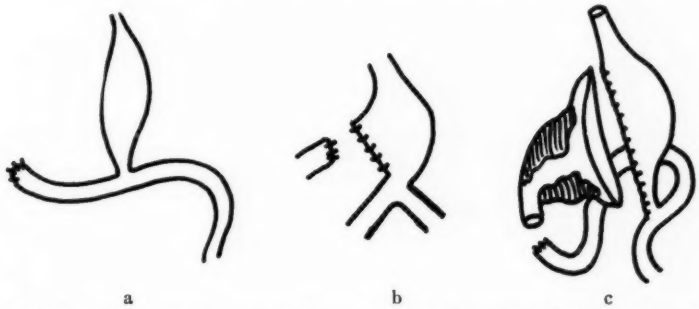


Fig. 8. The first end-to-side gastrojejunostomies. a, Kroenlein (1888) who operated for pyloric stenosis and found the duodenal stump too narrow for uniting it with the stomach and therefore implanted this in the jenunum (antecolic); b, Eiselsberg (1889) narrowed the small stomach stump which remained after the removal of a large cancer and implanted it in the jejunum (antecolic); c, Graser (1906), the first retrocolic end-to-side gastrojejunostomy—the remarkable lengthening of the stomach stump is the most prominent feature of this operation.

in performing the original end-to-end gastroduodenostomy, the classical Billroth I operation. Attempts were made to overcome this difficulty by dilatation of the duodenal opening, by cutting it obliquely, or by a longitudinal incision in its anterior wall. The only real help was found by narrowing the opening of the stomach. Only such part of it was left open as corresponded exactly with the opening in the duodenum. The partial closure was made usually on the lesser curvature, rarely on the greater or at both, and the weak point, the *Jammerecke*, the corner of sorrow, as the Germans call it, was at the junction of the occluding linear suture of the stomach and the circular suture which united stomach and duodenum. This place, the point where the three limbs of the T or Y formed by the lines of suture met, was in especial danger, first, because of necrosis as a result of the pressure of the sutures which may impair or even destroy the blood supply of the triangle-shaped bit of tissue which lies between them, and second because of the difficulty of covering this place with serosa adequately and without undue tension.

As to the second factor, any amount of tension must be very carefully guarded against when the stomach stump is co-aptated with the intestine if one wishes to avoid the untimely cutting through of the sutures or even necrosis caused by forceful stretching of the tissues. These dangers are imminent in every form of gastroduodenal anastomosis especially after extensive resections and in cases in which the mobility of the duodenum is slight or absent.

As to the third factor, disturbances in the emptying of the stomach contents, this problem must be guarded against in every form of gastro-intestinal anastomosis, but these disturbances are apt to become much more severe and generally they are also much more dangerous, when the jejunum rather than the duodenum is used for the anastomosis. And this is quite natural, because the gastroduodenal anastomosis presents nearly normal anatomical conditions for the passage of gastric contents. Swelling of the suture-line in consequence of edema or bloody infiltration, of course, may cause some transient upset in the emptying of the stomach contents as well as in producing subsequent stenosis which may become permanent. The latter occurrence is very rare when proper technique is used. After resections, however, which are completed by a gastrojejunostomy there may threaten all the disturbances which may arise after a gastrojejunostomy without previous resection: kinks especially, though rarely other forms of mechanical obstruction, may occur in the vicinity of the anastomosis immediately after the operation, and jejunal ulcers and their sequels may develop later. It is true

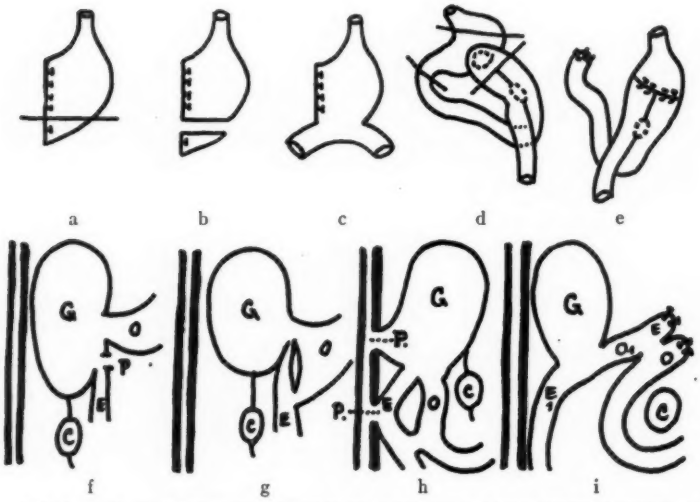


Fig. 9. a, b, c, "Corner-anastomosis" of Verebély. a, Closed stomach stump; b, corner at the great curvature cut off; c, stomach stump implanted in the jejunum; d, e, Fischer's operation; d, gastro-enterostomy and entero-entero-anastomosis (dotted lines) and lines of resection; e, stomach together with the opening of gastro-entero-anastomy and the top of the anastomotic loop removed, gastric passage restored; f, jejunal ulcer after retrocolic posterior gastro-enterostomy perforated; g, restoring of gastric passage by side-to-side entero-entero-anastomosis, the efferent loop being stenosed by the suture of the perforated ulcer; h, antecolic anterior gastro-enterostomy with side-to-side entero-anastomosis; stomach, *G*, in the neighborhood of gastro-enterostomy, and efferent loop, *E*, between the openings of the gastro-enterostomy and entero-entero-anastomosis into the anterior abdominal wall perforated, *P*; *C* transverse colon; *O* afferent loop. i, Condition after operation; resection of stomach together with the ulcerous efferent loop and the opening of gastro-enterostomy; afferent and efferent loops closed, entero-entero-anastomosis left, stomach stump implanted into the jejunum below the entero-entero-anastomosis. E_1 efferent, O_1 afferent loops of the end-to-side gastrojejunostomy.

that one important source of trouble in the passage of stomach contents after the ordinary gastro-enterostomy, namely, the patency of the pylorus, is eliminated by gastric resection, but if the pylorus is occluded the consequences are much worse than those which happen after an ordinary gastro-enterostomy.

If, after gastro-enterostomy, the contents of the stomach cannot leave it by the efferent loop, they regurgitate by the afferent loop and pass through the more or less open pylorus back into the stomach. But if there is no pylorus at all the contents stagnate in the duodenum, fill it, dilate it, and augment by stagnation in it, because the dilated duodenum is less able to expel its contents than the normal; for the muscles are stretched and at the same time have a more difficult task to perform. Under these circumstances when the contents of the stomach and the afferent loop cannot pass into the efferent loop (Fig. 10, b) or by the efferent loop (Fig. 10, a) the duodenum can empty only into the stomach and eventually its contents may be removed by vomiting. It is still better that the patient vomit than to have fluid remain stagnant in the duodenum, because the pressure of the dilated duodenum on the solar plexus may produce very serious and even fatal symptoms or it may cause insufficiency and perforation of the suture occluding the duodenal stump.

The situation is still more serious if a kink is located at the entrance of the afferent loop to the anastomosis (Fig. 10, c). Such a condition may entirely prevent the emptying of duodenal contents. It is true the duodenal

contents is composed chiefly of bile and pancreatic juice, but occlusion of the duodenum always causes a hypersecretion of these, so there may arise a vast accumulation of fluid in the duodenum, which cannot pass by any means out of the duodenum because its oral end is closed by the suture, its aboral by the kink. This condition may lead to rapid collapse and death, or may cause perforation of the duodenal stump into the peritoneal cavity.

This complication, a kink at entrance of afferent loop to the anastomosis, threatens especially in cases in which the stump of the stomach is too small and the small intestine has to be drawn highly upward for the anastomosis. Also there are some technical failures; for instance, faulty fixation of the mesocolic slit to the small intestine may produce it. It can certainly be avoided by an entero-entero-anastomosis between the two limbs of the anastomotic loop and therefore it is always wise to make this (preferably a small loop) as a safety-valve when the stomach stump is too small. However, especially in ulcer-cases the combination of gastrojejunostomy with entero-entero-anastomosis is not always harmless; it may help to produce a jejunal ulcer later.

Jejunal ulcer, the other serious complication which may follow gastrojejunostomy, is much less likely to occur when resection is done, than when resection has not been done and the patient has his entire stomach. It may occur nevertheless after resection, and in such cases it is much more difficult to deal with than when resection has not previously been done. The only sure means of avoiding jejunal ulcer is to keep the jejunal mucosa out of direct contact with the gastric juice, and that can be done only by gastroduodenostomy.

POINTS OF ADVANTAGE

There are two more points which deserve careful consideration: the ease with which the operation can be performed and the function of the stomach after different kinds of operations.

Ease in operating is chiefly dependent on the possibility of performing the operation outside of the abdominal cavity. The more one is able to do that, the easier the operation

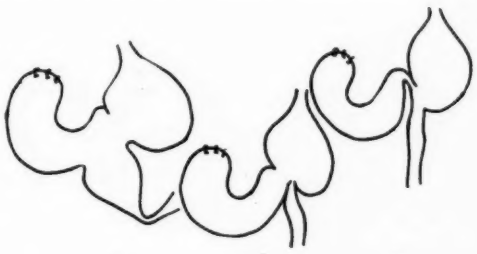


Fig. 10. Difficulties in passage of gastric contents after resection. a, Kink of the efferent loop; b, kink at the beginning of the efferent loop; c, kink at the end of the afferent loop.

and the surer the asepsis; also it facilitates the process of suturing and makes possible the minute control of the sutures. In addition, time is saved and this helps to avoid collapse, pneumonia, and other complications which may endanger the patient's life after operation. In this respect a gastrojejunostomy is generally superior to a gastroduodenal anastomosis, but not in all cases, and in many the difference may be eliminated. Regarding function, it is evident that the gastric passage reestablished after a gastroduodenal anastomosis more closely resembles normal anatomy than when a gastrojejunostomy has been made. Function is impaired after both, but it seems to be less so after gastroduodenostomy than after gastrojejunostomy. The functional value of any resected stomach is greatly diminished; removal of the pylorus deprives the stomach of the power to keep back its contents until satisfactorily prepared for digestion in the intestine; the removal of a considerable part of the musculature of the stomach impairs its contractile power so that its faculty to expel its contents by its own force is lost and the mixing, grinding, and triturating activities are quite impossible. Resection also abolishes the so called second, or chemical phase, of the secretion of gastric juice. The resulting hypacidity may be augmented or replaced by complete anacidity brought about by too extensive ablation of the secretory surface and by the reflux of bile and pancreatic juice, which may occur also through gastroduodenal anastomoses but generally is much more copious if

a gastrojejunal opening is present. Enderlen, Freudenberg and v. Redwitz showed that in the latter instance there is a possibility only of tryptic digestion in the resected stomach, whereas in the former the acidity is too low for peptic digestion but not low enough to permit tryptic digestion. This circumstance is of secondary importance because intestinal digestion can take the place of the missing gastric digestion. Therefore, the majority of patients feel perfectly well and gain weight after gastric resection. The chief cause of trouble, if there is any trouble at all, is the too rapid or too slow emptying of the resected stomach. As to the first, some patients feel permanently hungry, may be awakened by it at night. In the second instance, some patients feel a disagreeable fullness and heaviness after meals, sometimes even after a few mouthfuls and this distress may last for hours and may end with vomiting. The too rapid emptying (*Sturzentleerung*) of the stomach is typically peculiar to too broad gastrojejunostomies especially when the opening of the stump of the stomach is not narrowed before it is implanted into the jejunum. This condition is noted particularly soon after operation but later it may improve. The very slow emptying of the stomach may be caused by stenosis of the anastomotic opening, by ulcerous stricture of the duodenum or the efferent loop of the small intestine, or by shrinkage of adhesions. But also spastic contractions of the duodenum especially at the terminal part of the bulbus (Goetze) or of the small intestine (Schur) may hinder the propulsion of the gastric contents. The greater the amount of stomach removed the less will be the contractile power of the remaining stomach; the greater the part hydrostatic pressure will play in the emptying of the stomach, the greater will be the significance of the resistance the intestine may exercise against the progression of gastric contents.

Generally the patients with gastroduodenostomies present more favorable conditions than do those with gastrojejunostomies as far as continence as well as secretory activity is concerned. As to the gastrojejunostomies, functions of the retrocolic types and of those types with not too large openings are generally better.

Summing up, the conditions created by gastroduodenostomy come nearer meeting the physiological standard. This is borne out by clinical experience; on the whole, after gastric resection with gastroduodenostomy, patients complain less than do patients who have had a gastrojejunostomy, also they are less liable to late complications than the latter. On the other hand, gastrojejunostomies are generally easier and safer to perform.

TECHNICAL DIFFICULTIES

The technical difficulties encountered in doing a gastroduodenostomy are due chiefly to the immobility of the duodenum. This varies in different cases. In certain cancer cases, especially in thin people with ptotic stomach, the upper transverse portion of the duodenum is often very much elongated; in such patients the coaptation of the gastric and duodenal stumps is generally very easy. In the presence of duodenal ulcer, however, the duodenum is usually quite immovable, very often it is embedded in hard adhesions especially when the ulcer is on the posterior wall and penetrates into the pancreas. In such a case the duodenum can never be mobilized sufficiently to be used for end-to-end gastroduodenostomy. But there are cases in which the duodenum is not fixed by strong adhesions, but only by such as are easily divided. Other times it is quite free but too short to be brought in contact with a not very large stomach stump. In such cases Kocher advised mobilization of the duodenum. Generally it is much simpler and easier to lengthen the stump of the stomach. The difference in size of the openings must be adjusted in any case, and this may be accomplished in a way which helps to co-apt the duodenum with the stomach. If the stump of the stomach is cut and sewed in the proper way, it becomes a cylindrical structure, a tube very similar to the small intestine; thus the difficulties in gastroduodenal suture are reduced to those of a circular intestinal suture. And if one uses this tube-like stomach stump for the gastroduodenal suture after the through-and-through and serosal sutures partially closing the stomach stump are perfectly completed, then the much dreaded place of

meeting of the two suture lines loses all its perilousness. Two structures entirely covered with serosa are to be united; therefore, there is no danger provided union can be accomplished without any tension and this is generally possible when the gastric stump is prepared in the proper manner.

When properly done, therefore, the gastroduodenal suture is not only as easy as the circular suture of the small intestine, but it is likewise as safe; safer indeed because there is no mesenteric border where the covering with serosa is imperfect. Thus the *Jammerecke* is completely eliminated.

And not only for the end-to-end gastroduodenostomy, but also for every other form of gastro-intestinal anastomosis in which the opening of the stump of the resected stomach is to be united with or implanted into the wall of the intestine—this tube-like form of the stomach stump has many advantages because:

First, its length (1) relieves the tension and facilitates coaptation as well as the placing of the sutures; (2) makes room so that soft clamps may be applied and in this way asepsis is promoted; (3) helps asepsis in that it is possible to do the suturing outside of the abdomen thus making perfect isolation feasible.

Second, narrowing the lumen–not only makes suturing easier by reducing the gastric lumen, but also favors later function—for the rapidity of the evacuation of the stomach stump is diminished.

Third, the chief advantage, however, is the perfect covering with serosa. This insures safety in the suture; the weak points, for instance, the fat and the ligated blood vessels of the lesser curvature, may be not only covered with serosa, but are far from the line of the circular suture. The longitudinal occluding suture line of the stomach already covered with serosa causes no difficulty whatever in making the circular suture. If done properly, the two suture lines do not weaken each other: on the contrary, they are made stronger by covering each other with a new layer of serosa.

THE TUBE-LIKE FORM OF STOMACH STUMP

The tube-like form of the stomach stump is certainly the most useful, therefore, it is wise to fashion it into this shape in every case in which one has to re-establish gastro-intestinal continuity after gastric resection. There are of course some exceptions, for instance, in secondary resections when a gastro-enterostomy has previously been made, and when one must remove only that part of the stomach which lies between the duodenum (pylorus) and the gastro-enterostomy and then close the lines of resection.

Of the aforementioned forms of the gastro-intestinal anastomosis I *prefer end-to-end gastroduodenostomy;* if this is not feasible because of the condition of the duodenum, I prefer retrocolic partial inferior end-to-side gastrojejunostomy. Which of the two is to be chosen is often quite evident at first inspection after the opening of the abdominal cavity, but sometimes a decision is reached only after the removal of the diseased part of the stomach.

The advantages of gastroduodenostomy over the gastrojejunostomy have already been discussed. One purely technical point may be added. Stomach and duodenum lie in the so called upper story (*etage*) of the peritoneal cavity, which is well separated from the lower and much larger section by the transverse colon and mesocolon. Gastroduodenostomy is of value if in the course of an abdominal operation one is able to limit it to a strictly circumscribed area which can be perfectly isolated during and after the operation. If a gastroduodenostomy is made, one avoids tampering with the small intestine; in fact one need not even see one loop of it. For this reason the danger of postoperative adhesions, which may cause very disagreeable complications immediately as well as eventually, months and years after operations, is diminished. By all means it is always wise to limit the field of operation, unless other important considerations require the contrary. Here again is a point in favor of gastroduodenostomy if it is feasible and safe in a given case. Another point in its favor is that occlusion of the mesocolic rent, which has some awkward features, is avoided with gastroduodenostomy.

As already mentioned, it is chiefly the condition of the duodenum, especially if a duodenal ulcer is present, which makes it impossible to perform an end-to-end gastroduo-

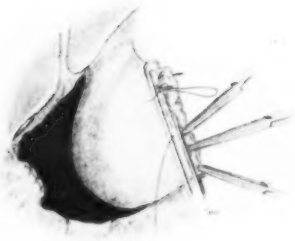


Fig. 11

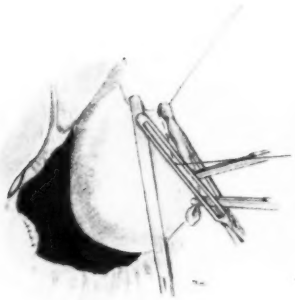


Fig. 12

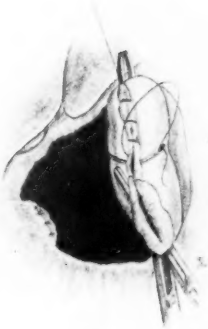


Fig. 13

Fig. 14

Fig. 11. First step in partial occlusion and lengthening of the stomach stump. Temporary occlusion of the upper part of the resection line of stomach by mattress-suture.

Fig. 12. Second step in partial occlusion and lengthening of the stomach stump. Removal of the fenestrated clamp; the artery clamps ensure against the retracting of the stomach wound; generally they are not necessary if one works fast enough, the crushed edges of the wounds sticking to each other.

Fig. 13. Third step in partial occlusion and lengthening of the stomach stump. Definitive partial occlusion of the stomach wound by suture which goes through its whole thickness; it is better if lockstitch sutures be used instead of simple continuous sutures.

Fig. 14. Fourth step in partial occlusion and lengthening of the stomach stump. Seroserous sutures covering the through-and-through sutures. The first stitches fasten the serosa in proper place.

denostomy. If we cannot secure a circular, well nourished, movable tube of duodenum at least 2 centimeters long, it is better to desist from it. While in certain cases the line of resection of the duodenum is manifestly useless for circular suture, it is found that the section of duodenum which lies behind the duodenal ulcer or scar is broad, easily accessible and covered with healthy serosa, and measures in length at least 5 to 6 centimeters. In such cases it is preferable to make an end-to-side gastroduodenostomy for the gastric stump can always be shaped to the most convenient form in cases of duodenal ulcer.

Except in these cases, which are very few indeed, in all other cases in which the end-to-end gastroduodenostomy cannot be performed, the retrocolic end-to-side gastrojejunostomy with a tube-shaped stomach stump is the operation of choice. The retrocolic method is to be preferred to the antecolic because it creates better conditions for the undisturbed passage of gastric contents and presents less possibilities for intestinal obstruction. It is true that antecolic gastro-enterostomy is easier to perform and that its failures are generally easier to be remedied than are those after retrocolic operation. Such failures, however, are more frequent and more inevitable with antecolic than with retrocolic anastomoses—if they are properly performed. The remedy for the failures of gastrojejunostomy—jejunojejunal anastomosis—particularly in ulcer cases is not without danger to the future welfare of the patient. Therefore, it is better to avoid it if at all possible. The only situation in which one must not fear an entero-entero-anastomosis and in which it should always be done is the presence of a very small stomach stump which is supposed not to produce sufficient

Fig. 15

Fig. 16

Fig. 17

Fig. 15. First step in end-to-end gastroduodenostomy. The first serosa-stitches are in place, uniting stomach stump and duodenum; they are laid on a tag of omentum. At the operation there is of course a strip of gauze between them, until the anterior row of through-and-through sutures is finished.

Fig. 16. Second step in end-to-end gastroduodenostomy. The artery clamps occluding the stumps are taken away and the posterior row of through-and-through sutures is begun.

Fig. 17. Third step in end-to-end gastroduodenostomy. The anterior row of seroserous suture.

Fig. 18. Fourth step in end-to-end gastroduodenostomy. The anterior portion of the seroserous suture is covered with the omental tag.

Fig. 18

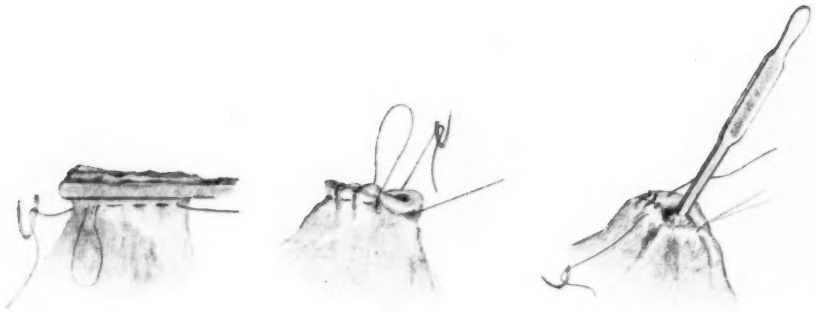
hydrochloric acid as to cause an ulcer. In such cases the antecolic operation also has the advantage that the difficulties of closing the mesocolic rent are eliminated and in cases of highly situated, small stomach stumps such difficulties may be very great indeed.

Antecolic anastomosis may be preferable, too, when adhesions or other anatomical changes around the first jejunal loop present difficulties, for instance when the resection is done for jejunal ulcer, whereas adhesions of the stomach and mesocolon are to be severed in any case if the former is to be resected, except in very rare instances when the transverse colon must be removed as well.

In certain cases if the stomach is not dilated and the cross section of it is exceptionally small, its stump may be directly implanted unnarrowed in the jejunum. In the most cases, however, a tube-shaped stump is far better.

FORMING THE GASTRIC STUMP

The technique of properly forming the gastric stump is quite simple. The stomach is cut obliquely from left to right and from above downward (Fig. 7, g, *a*). In this way more of the lesser curvature is removed than of the greater one. This is generally desirable in cases of gastric cancers and in gastric ulcers



a b c

Fig. 19. Closing of the duodenal stump. a, Temporary closure by through-and-through mattress-suture; b, final through-and-through continuous suture, by drawing together the thread the stump is diminished; c, tucking in the stump and covering it with serosa.

as well because an affection on the lesser curvature is usually more extended than on the greater one. In the presence of duodenal ulcer, however, it is indifferent. The obliquity of the line of resection must certainly not be exaggerated. The cutting is done between two hard clamps. On the oral side I prefer to use a fenestrated clamp (Graser's). Through its middle slit I apply a continuous mattress-suture with catgut, going through both walls of the stomach and keeping them temporarily together (Fig. 11). The suture begins at the lesser curvature and ends 3 to 5 centimeters over the greater curvature. The beginning of the thread is left long and armed with a second needle. The opening of the stomach should be left somewhat wider when end-to-side gastrojejunostomy is intended than when gastroduodenostomy is to be made.

When the part which is to be occluded is temporarily fixed by this thread, a soft clamp is put on 3 to 5 centimeters behind the hard clamp and the latter taken away (Fig. 12); the unstitched part of the stomach wound, which was crushed by the clamp, is grasped by a narrower clamp; I generally use Kocher's artery forceps. The tip of this should lie at the point where the last stitch of the mattress-suture emerges from the stomach. During this time the assistant holds the line of resection by stretching the thread. Now while he keeps tense the end of the thread which lies nearest to the greater curvature, one unites the stomach wound with the needle left on the beginning of the thread by continuous through-and-through suture (Fig. 13) until one reaches the end of the mattress-suture and ties both ends of the thread together. After this, the soft clamp is removed. It is advisable to accomplish the occlusion of the stomach stump by lockstitch sutures in order to prevent bleeding quite surely.

Then this occluding suture is covered with serosa (Fig. 14). I prefer for this interrupted sutures the last of them put on immediately over the tip of the occluding artery-forceps. One must take broad serous surfaces to cover quite securely the through-and-through suture; at the oral end this serosa-suture must overreach the end of the through-and-through suture by 2 to 3 centimeters. If feasible without any tension, even the ligated stumps of the vessels of the lesser curvature should be turned in and the serosa-suture continued to this point.

END-TO-END GASTRODUODENOSTOMY

End-to-end gastroduodenostomy requires that the end of the elongated tube-like stomach stump and the free part of the duodenum be easily brought together; also it must be possible to coapt 2 to 3 centimeters of them without any tension. This point must be definitely assured before one decides finally to make the end-to-end gastroduodenostomy bringing in contact the stumps of the stomach and the duodenum, which is likewise held by a Kocher artery forceps. Before the suture is

Fig. 20

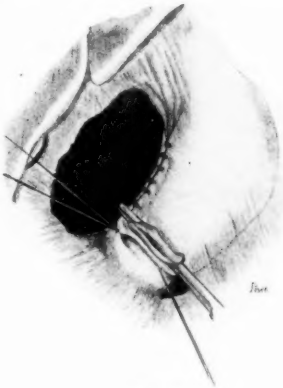


Fig. 21

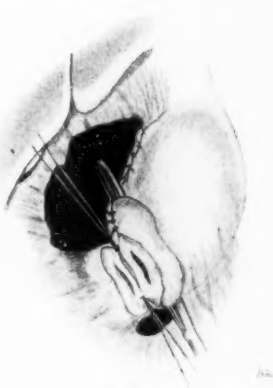


Fig. 22

Fig. 20. First step in end-to-side gastroduodenostomy. The stomach stump is being brought toward the closed duodenal stump.

Fig. 21. Second step in end-to-side gastroduodenostomy. The first stitches of the posterior row of serosa sutures.

Fig. 22. Third step in end-to-side gastroduodenostomy. Opening of the duodenum.

Fig. 23. Fourth step in end-to-side gastrojejunostomy. The seroserous suture is finished.

Fig. 23

started it is wise to look for a long tag of omentum. The tip of this caught with an artery-forceps is brought upward and laid below the meeting-place of the stomach and the duodenum to be united. It should be isolated by a thin strip of gauze. Now the stumps of the stomach and the duodenum occluded by Kocher forceps are laid over this and the uppermost serous stitch made (Fig. 15). It should go 1.5 centimeters above the last stitch of the occluding linear serous suture of the stomach and 1 to 1.5 centimeters behind the artery forceps occluding the end of the duodenum at its upper border. This stitch is tied whereas the stitch which unites the inferior border of the duodenum with the greater curvature 1 to 1.5 centimeters behind the Kocher forceps is not tied although it is inserted when the posterior row of the seroserous suture is begun. Now the posterior surfaces of the gastric and duodenal stumps are united with interrupted Lembert sutures, beginning at the lesser curvature and continuing to the greater curvature until the last suture, which was left loose, is reached. Then this is tied likewise. Now a soft clamp is put on the stomach 3 to 5 centimeters behind the suture line and after careful isolation the Kocher forceps are removed, and the full thickness of the edges of the gastric and duodenal stump is sewed together with continuous catgut suture from the inside as far as possible (Fig. 16). Generally this is easily possible for at least three-fourths of the suture line. One begins at the lesser

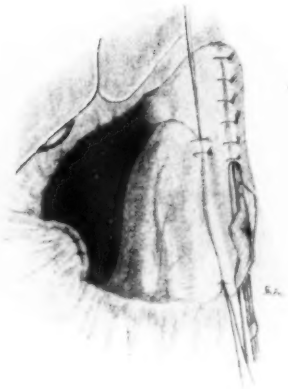


Fig. 24

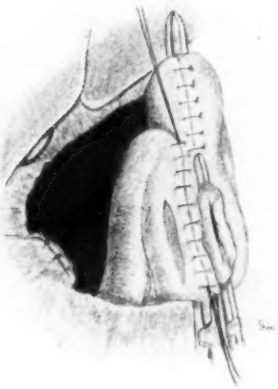


Fig. 25

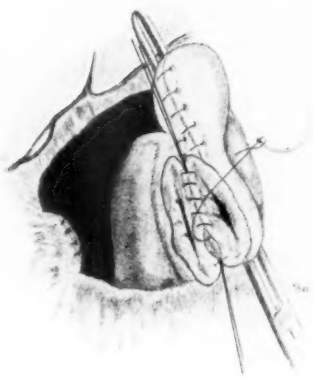


Fig. 26

Fig. 27

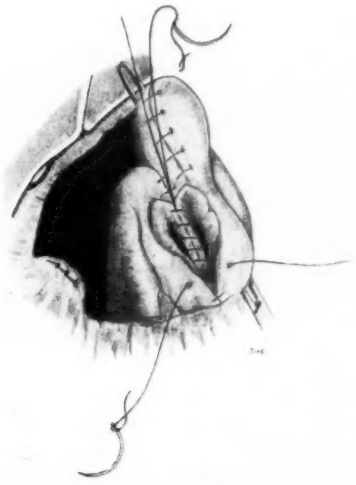


Fig. 28

Fig. 24. First step in end-to-side gastrojejunostomy, partial inferior. The first stitches in the posterior row of the serosal sutures to unite jejunum and stomach stump are shown.

Fig. 25. Second step in end-to-side gastrojejunostomy. Opening of the jejunum.

Fig. 26. Third step in end-to-side gastrojejunostomy. The posterior row of the through-and-through sutures uniting stomach and jejunum are shown. Lock stitches are better but the drawing seemed clearer with simple continuous suture.

Fig. 27. Fourth step in end-to-side gastrojejunostomy. The posterior row of the through-and-through sutures is finished. The stitch uniting the greater curvature to the jejunum which was left long and pulled by the assistant to co-apt the edges of the wounds of the stomach and jejunum, is cut short. Another stitch which penetrates the whole thickness of stomach and jejunum is put in at a distance of 2 to 3 centimeters from the above mentioned stitch. This is tied, kept stretched by the assistant, and the continuous suture is continued from inward.

Fig. 28. Fifth step in end-to-side gastrojejunostomy. The suture from inside is finished after the end of the thread is tied to the last interrupted stitch. Immediately over it a stitch is placed from the outside which turns in the mucosa. This is tied, left long, and given to the assistant to pull. The upper end of the thread of the continuous suture which was left long is armed with a needle.

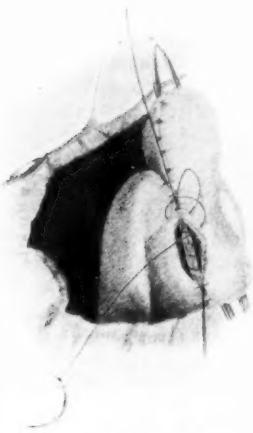


Fig. 29

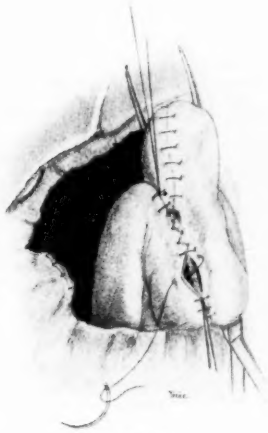


Fig. 30

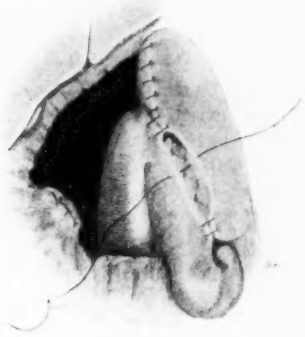


Fig. 31

Fig. 32

Fig. 33

Fig. 29. Sixth step in end-to-side gastrojejunostomy. The anterior row of the through-and-through suture is continued from outside the mucosa and being turned in the serosal surfaces co-apted.

Fig. 30. Seventh step in end-to-side gastrojejunostomy. The soft clamp is removed just before finishing the anterior row of through-and-through sutures. One or two interrupted sutures were inserted earlier to secure right co-aptation of the wound in the middle of the wound or on both ends of its middle third.

Fig. 31. Eighth step in end-to-side gastrojejunostomy. The first and last serosal stitches which were left long until now are cut short and covered with new serosal stitches. Other interrupted serosal stitches are put in if necessary to coapt the serosa exactly.

Fig. 32. Ninth step in end-to-side gastrojejunostomy. After this continuous suture, the anterior row of sutures is finished.

Fig. 33. Tenth step. The mesocolic rent is stitched to the stomach with a few interrupted sutures.

curvature, leaving the thread long at the beginning and placing the suture on the inside carefully co-apting the margins of the wounds of the mucosa. If a stitch is previously placed at the site of the greater curvature the suturing is facilitated (see Fig. 26). When one reaches this stitch, another is put in 2 or 3 centimeters farther, from the inside (Fig. 27). This is tied, and the assistant pulling on it turns out the mucosa, and the continuous suture is started. If the suture from the inside cannot be further continued, the end of the thread of the continuous suture is tied to the last stitch, cut short, and the mucosa is turned

in again. Now a through going stitch is inserted at this point and tied from the outside (see Fig. 28). The beginning of the thread which was left long is armed with a needle and the remaining gap is closed with through going continuous suture (see Fig. 29) until the last stitch is reached and tied. Shortly before this the soft clamp must be removed (see Fig. 30). After this the seroserous suture is completed on the anterior wall (Fig. 17), preferably with interrupted sutures. One or two seroserous sutures are placed above and below the last stitches of the posterior seroserous row which had been left long, and they are covered after cutting with one or two Lembert stitches. When the seroserous suture is finished the tag of omentum which already covers the posterior surface of the suture is placed on the anterior surface as well (Fig. 18). In this way the whole suture is packed in omentum. To fix this omental tag by suture is quite unnecessary; it covers the suture abundantly and does not move from its place if not pulled down forcibly.

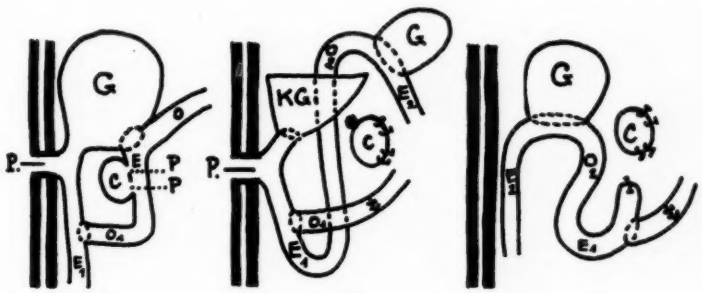
END-TO-SIDE GASTRODUODENOSTOMY

End-to-side duodenogastrostomy (Kocher's operation) was the method I preferred when a beginner. However, it involves mobilization of duodenum, and although generally very simple and quite bloodless, at times may be followed by bleeding from small vessels, and, being retroperitoneal, is never unimportant and may be quite disagreeable. The form of the stomach stump is also not always suitable for the Kocher operation. One may do a Billroth I easily in cases in which the Kocher operation is quite impracticable. The occluding suture of the stomach is also a factor as it takes time quite unnecessarily. I therefore discarded this method entirely. But in some cases already described end-to-side gastroduodenostomy (Finney, Haberer) may be preferable. If one wishes to attempt this method, it is advisable to save as much as possible of the duodenum, preferably the whole—and therefore leave the diseased part of the duodenum untouched and do the resection on the gastric side of the pylorus. The small funnel of gastric mucosa remaining is excised, and the muscularis is closed and covered with serosa. The properly prepared stomach stump the end of which is held by a Kocher artery forceps is now placed on the anterior surface of the already closed duodenum (Figs. 19 and 20) the occluding suture of the stomach to the right and upward, the greater curvature to the left and downward at least 1 to 2 centimeters from the occluding duodenal suture. At each of these points one seroserous stitch is inserted and tied (Fig. 21). The partial occluding suture of the stomach is applied as near to the upper border of the duodenum as possible and between them a whole row of interrupted Lembert sutures to complete the posterior serosal suture; now a soft clamp is placed on the stomach stump as far as possible from the suture-line, the duodenum is incised parallel to the opening of the stomach and as far as possible in the longitudinal axis of the duodenum which corresponds here to the transverse axis of the body. The incision is ¾ centimeter underneath the serosal suture and is somewhat shorter than the gastric wound. The artery forceps, which is occluding the stomach stump (Fig. 22) is now removed. The wounds are sutured with catgut, through-and-through continuous sutures, as far as possible from the inside. When the through-and-through suture is completed and the soft clamps are taken off, the suture as well as the last serosal stitches of the posterior row which were left long and only now cut is covered with serosa (Fig. 23) continuous or interrupted, as it seems safer and handier. The whole is then covered with omentum.

END-TO-SIDE GASTROJEJUNOSTOMY

If end-to-side gastrojejunostomy should be performed, the stomach stump is first prepared and then the duodenal wound is closed by ligating or sewing and turning in the stump and covering it with at least two rows of serosa, the second of which may unite the anterior surface of the duodenum with the pancreas.

In the presence of duodenal ulcer when the dissection of the duodenum or its reliable covering with serosa seems difficult or even dangerous or impossible, the resection should be done rather at the gastric side of the



a b c

Fig. 34. a, The condition present in a 39 year old man who had already had five stomach operations done by as many different surgeons. There was a retrocolic posterior and an antecolic Y-shaped gastro-enterostomy. The jejunal ulcer which developed at the site of the posterior anastomosis had 3 perforations: two in the colon, one to the anterior abdominal wall (this last one is not depicted in the drawing) at the efferent loop of the Y-shaped anastomosis, one jejunal ulcer breaking through the abdominal wall and producing there a fistula. b, Condition after the first operation excluding the part of the stomach which contained the anterior gastro-enterostomy; the posterior gastro-enterostomy was disconnected, the openings of the transverse colon closed, the stump of the stomach implanted into the jejunum below the entero-entero-anastomosis, which appertained to the V shaped gastro-enterostomy. c, The second operation removed the excluded part of the stomach with the anterior gastro-enterostomy and its efferent loop. *G*, Stomach; *K G*, excluded stomach; *C*, transverse colon; *P*, perforation; *O*, afferent, *E* efferent loop of the retrocolic gastro-enterostomy; O_1, afferent, E_1, efferent loop of the Y-shaped gastro-enterostomy; O_2 afferent, E_2 efferent loop of the end-to-side gastrojejunostomy.

pylorus, and this wound should be closed as described.

Chiefly 3 points must be remembered here: (1) the friability of the duodenal wall which may be such that every suture cuts through; (2) the rigidness which may make its tucking in quite impossible; (3) the close proximity to the common duct which in cases with duodenal ulcers may lie surprisingly near the pylorus and may subsequently be injured by the dissection or by the suture.

After the duodenal stump is closed, gloves and isolating material are changed, the transverse colon is lifted, drawn upward, and the first loop of the jejunum is sought and brought through a longitudinal incision in the bloodless part of the transverse mesocolon in the operating field. Then the transverse colon and the omentum are put back into the abdomen. One must determine very exactly the site and direction of the first jejunal loop, which is used for the anastomosis, so that every kink or torsion of it be surely avoided. It is best to take the part of the jejunum which lies 10 to 12 centimeters below the plica duodenojejunalis for the anastomosis. Here, in the vicinity of the left mesenteric border, should be placed the first stitch which fixes to the jejunum the occluding suture line of the stomach about 1 to 1.5 centimeters behind the occluding Kocher forceps. The occluding suture of the stomach is laid nearest to the plica. Then the last stitch of the posterior serous row, which fixes the greater curvature to the mesenteric border of the jejunum, is inserted (Fig. 24) and between the two the posterior serosal row of sutures is completed. It is best to use interrupted sutures and to take care not to injure the great vessels which lie here under the serosa of the jejunum. Then a soft clamp is placed on the stomach, the incision of the jejunum is made (Fig. 25) in its longitudinal axis about ½–¾ centimeter from the posterior serosal suture (to clamp the jejunum is superfluous) and somewhat shorter than the wound of the stomach. Then a catgut through-and-through suture unites the jejunum with the stomach, as much of it as possible being done from the inside and with continuous sutures (Figs. 26 to 29). The soft

clamp is taken off shortly before this through-and-through suture is completed (Fig. 30) and after this row of sutures is completed the anterior row of seroserous suture is made as described (Figs. 31 and 32). One makes sure by invaginating the wall of the efferent loop with the index finger that the anastomosis is quite permeable. Then lifting the transverse colon again one returns the jejunum to its place, again makes sure that there is no kink or torsion, or any other irregularity, and finally sews the rent in the mesocolon to the stomach wall about 1 to 2 centimeters away from the suture line (Fig. 33). It is not good to sew it to the suture line and still worse to sew it to the jejunum.

The gastrojejunal suture line lies below the transverse mesocolon. In the cavity which remains over the transverse colon and mesocolon it is well to put omentum to cover the occluding gastric suture as well as the duodenal stump.

ANTECOLIC END-TO-SIDE GASTROJEJUNOSTOMY

If the stomach stump is too small, antecolic end-to-side gastrojejunostomy with side-to-side jejunojejunal anastomosis is the safest method, as already mentioned. The best place in the jejunum for antecolic gastric anastomosis lies 30 to 50 centimeters from the duodenojejunal fold. The anastomotic loop by no means should be too short because this would predispose to its compression by the transverse colon as well as to kinks. Jejunojejunal anatomosis is best made at a point where the two loops can be brought the most easily together, generally about a hand's breadth below the gastro-enterostomy. Other technical details are identical with those already described. One must take care to avoid torsion and the creation of pouches which may cause earlier or later intestinal obstruction. Also there are cases which require special measures. Figure 34 shows a case of mine with two gastro-enterostomies and 4 perforations due to jejunal ulcers, two into the colon and two into the anterior abdominal wall. One of the latter developed a broad fistula, through which intestinal contents copiously flowed out. In this case I operated in two stages. At the first operation I disconnected the posterior gastro-enterostomy, closed the colic fistulas, and after dividing the stomach transversely and implanting its oral part into the jejunum, closed and excluded its aboral section which still contained the anterior gastro-enterostomy. In the second operation I extirpated the excluded part of the stomach and removed the fistulous small intestine connected with it, closing the stumps of the duodenum and the jejunum. Figure 9, f and g, shows on the other hand a very simple method for restoring the gastro-intestinal continuity after perforation of a jejunal ulcer into the free abdominal cavity. The method is especially useful when the presence of pyloric stenosis makes restoration by simple disconnection of the gastrojejunostomy impossible and when at the moment resection is at least inadvisable. The perforation is sutured, and if this causes stenosis of the efferent loop entero-entero-anastomosis between the efferent loop (below the stenosis of course) and the afferent loop re-establishes passage. Later a resection may be done in the manner shown in Figure 9, h and i.

Many other peculiarities may be met making other procedures advisable—many roads lead to Rome, and circumstances must guide us in choosing the best method. Sometimes it may prove a difficult problem to find the right one.

OPERABILITY AND FACTORS THAT INCREASE CURABILITY OF CARCINOMA OF THE RECTUM

T. E. JONES, M.D., F.A.C.S., Cleveland, Ohio

WHEN the diagnosis of rectal cancer has been made, the problem that next confronts the surgeon is the question of operability. Operability factors include age, general condition of the patient, extent and fixation of the local process and, finally, metastases to distant parts. Operability is variously quoted even in recent literature as ranging between 30 and 70 per cent. These facts must cause considerable confusion to the reader. Until we adopt some simple plan and method of calculating our statistics on operability, they will be meaningless and uninteresting figures because one cannot compare his own work with that of others and see where he stands. Comparison is instructive and inspires all of us to better accomplishments. When one sees surgeons of equal capabilities having a variance of from 30 to 70 per cent in operability figures, it means that they have entirely different methods of analyzing their statistics. If we are in earnest about gathering statistics of value as to the sanest and safest way to cope with the problem of carcinoma of the rectum, it seems to me that we can do it very simply because here, at least, we speak the same language.

Generally speaking, the lower the operability rate the higher the curability rate, because one usually takes for radical operation only the early cases, and does palliative operations on the doubtful or advanced cases. This may or may not be true, but it could be ascertained if all the facts were presented. Pertaining to this very point, I may say that Miles, of London, quotes an operability of 30 per cent. Not long ago while conversing with him on the subject, he made the statement that he meant he operated on 1 out of every 3 patients he saw and he counted them all. When one considers his leadership in this field and the fact that he has had a large service at the Cancer Hospital where many derelicts are sent, his operability would be 60 or 70 per cent as compared on an equal basis with that of others.

There are various operability factors to be analyzed. Many writers in the past have automatically set an age limit at 60 or 65 years but, after all, age in number of years does not tell the whole story. Many a man at 70 may be a better risk than a man at 60. While his life expectancy may not be as long, we cannot stand by and do nothing on account of age alone. The prolonged, terminal suffering of these individuals is a challenge to the surgeon to fulfill his obligation to the utmost.

Several months ago I was confronted with the problem of a man 73 years of age with a very doubtful operable carcinoma of the upper rectum, completely fixed to the seminal vesicles and the peritoneum at the rectovesical pouch. A combination of factors, namely, a lean, wiry type of individual otherwise in good health, with no obvious metastases, and a request to be given every possible chance, led me to proceed with the operation. A combined abdominoperineal operation in one stage, including the seminal vesicles in one mass, was performed. He made an uneventful recovery and left the hospital on the seventeenth day. In a very obese man even at 60 years of age this might not have been very good judgment. Experience frequently lends a guiding hand.

Location and fixation. This has a bearing on operability. Generally speaking, we consider a growth on the anterior wall in proximity to the bladder, seminal vesicles, and urethra as more difficult than one on the posterior wall, especially if attended with fixation. Considerable fixation on the posterior wall may be removed more easily than moderate fixation anteriorly. It is frequently impossible to estimate whether fixation is due to inflammatory reaction or malignant invasion. From one's experience, it is correct to assume that at the

From the Cleveland Clinic.
Presented before the Clinical Congress of the American College of Surgeons, Philadelphia, October 16–20, 1939.

time of operation it is more likely that the larger percentage will be inflammatory. Obviously, the morbidity from possible damage to the bladder, ureter, or urethra will be greater from fixation anteriorly than posteriorly. A thorough digital examination to estimate these points is very valuable.

Obstruction. The rectal ampulla is large, and a growth must reach a very large size before obstruction ensues. If, however, the growth is at the rectosigmoid, obstruction takes place sooner. The history and examination of the abdomen will give the desired information. Obstruction in itself is no contra-indication to operation, and if not relieved by medical means, the surgeon may resort to a preliminary colostomy.

Obesity. Obesity constitutes a formidable block for several reasons. We know that in the obese individual, regardless of the location of the malignancy, cancer seems to spread faster than in the "smoked herring" type of individual. Obese individuals also seem to tolerate infection poorly. From a technical standpoint, the operation is much more difficult and time-consuming so that if one has a combination of fixation in the obese individual, the risk is far greater than in a thin one, both from the immediate mortality and the ultimate results. Sometimes the mesentery is so thick in these individuals that one may have extensive glandular involvement in the mesosigmoid and along the aorta which it is impossible to palpate. This condition, of course, renders the ordinary case inoperable.

Size of the growth. One need not be discouraged by a large growth even though there may be some fixation. Experience shows that in many such growths there may not even be any glandular involvement. Frequently the prognosis is much better than with small growths of a more malignant nature which have already formed metastases. I recall several large, bulky tumors of the rectosigmoid which had intussuscepted into the rectum, making the mass seem to appear much larger than it really was. Other factors led to exploration and finally to satisfactory end-results.

Loss of weight and anemia are not necessarily contra-indications to exploration. Unless one actually demonstrates metastases to the liver or lungs, the patient should be explored. We must remember that many of these patients complain of diarrhea. They think that its correction lies in dietary measures and this frequently accounts for loss of weight and secondary anemia. The anemia can be corrected easily by blood transfusion and then an exploratory operation can be done safely.

Associated chronic diseases, such as diabetes, tuberculosis, and cardiorenal disease may occur in patients with carcinoma of the rectum, but they do not necessarily spell inoperability. It is important to emphasize at this point that operation for cancer of the rectum is not an emergency procedure. Plenty of time can be taken to rehabilitate the patient. Too frequently, upon the finding of a carcinoma, both physician and patient become hysterical and demand prompt action. This hurry has cost many lives. These patients should be put in the hands of specialists in their various lines, and the eager surgeon should be handcuffed until the optimum time for surgery.

These foregoing factors relative to operability may be estimated before operation. However, there are some facts that cannot be estimated before exploration. These are metastases to the liver or glands or fixation inside which could not be ascertained from rectal examination. Metastases to the liver make it incurable while the local lesion may be entirely operable. Personal equation enters into the handling of such a case. In addition to striving for cure, the surgeon has another great obligation in case cure is not possible: the relief of pain. For that reason I have many times completed the operation when there was liver involvement and have no reason to regret it. The pain and discomfort in the terminal stage is terrific and one must not protect his statistics to the point of allowing the patients to suffer. In a case where there is not much liver involvement, with the patient in a fair state of preservation, and with an operable lesion in which one does not take more than the average risk, I think it is our duty to remove it for the patient's comfort. I think that in this type of case, palliative colostomy

is resorted to too frequently. We must distinguish the pain of obstruction from the pain of metastases. If the patient has no obstruction, colostomy does not give him any relief. In fact, it adds to his misery on account of the nuisance of the colostomy. Colostomy does not relieve the pain of metastases, and with the lesion *in situ* the patient still has what is so distressing, namely, frequency and urgency due to the mucus, pus, and blood from the ulcerating neoplasm. If the lesion is resectable, it should be done in preference to colostomy. Involvement of the mesenteric lymph glands constitutes one of the criteria of operability; but in my mind it is of minor importance because very frequently one cannot feel any glands in the fat, thick mesentery when there may be extensive glandular involvement. On the other hand, when one can feel them, it is frequently impossible to tell whether these glands are inflammatory or malignant, so that unless glandular involvement has increased to the point where there is fixation to the sacrum or lateral pelvic wall, the surgeon should proceed with the operation. Here again, the curability rate may be affected in one sense, but many whose enlarged glands turn out to be inflammatory will also be saved who otherwise would not.

Fixation to the seminal vesicles, bladder, and pelvic wall that cannot be determined until operation may contra-indicate operation in most cases. In women, however, fixation to the uterus does not make it inoperable. In 3 of our patients the uterus has been successfully removed with the rectum in one mass.

In recent years another criterion of operability has been added, namely, gradation of tumors. It increases our knowledge regarding cancer, and may prove valuable from a prognostic standpoint, but I am opposed to using gradation of tumors as a guide to therapeutic effort. If a case is clinically operable, I would not refuse operation because the pathologist said it was grade 4. The pathologist has been known to make mistakes.

Operability, then, is determined after an appraisal of all of the above mentioned factors. One must consider the patient as well as his disease. My philosophy regarding cancer of the rectum is to increase the scope of operability constantly. The mortality may be increased a little but we will keep the patients comfortable for a longer period of time, and relatively more people will be alive at the end of 5 years than with a lower percentage of operability.

The type of operation must be left to the judgment and experience of the surgeon and to his facilities. Based upon my experience with cancer of the rectum, it is my belief that the abdominoperineal resection for carcinoma of the rectum offers the greatest hope of cure or immunity for a longer period of time than any other procedure. I am speaking of the great average number of cases who come to the surgeon. There are, of course, minor procedures which give occasional cures, namely, electrocoagulation or radium treatment of those patients who come to us in whom the carcinoma is limited to the mucosa. I have seen a number of this variety but in contrast with the total this group is so in the minority that it is almost useless to talk about them. It would be a happy period for the surgeon should the time arrive when we could see all of these cases early when a minor procedure, namely coagulation or radium, would give as high a percentage of cures as the most radical operation practiced today. Unfortunately, I must admit that the cases today in my experience are just as far advanced as those observed 20 years ago in spite of propaganda or education along these lines. This is due to a variety of circumstances that cannot be touched upon in this paper, but they are chiefly delay on the part of the patient in consulting the physician, when he knows that something is wrong, and neglect on the part of the physician to make an investigation when the patient does consult him.

Obviously, the greatest factor in increasing the curability rate is early diagnosis. It is unnecessary for me to state that half of these patients have been treated for hemorrhoids for months before they come to operation. It is not the wish of the profession to raise a race which may be addicted to cancerphobia. Such individuals often suffer just as much as the cancer patient himself. A thorough digital and proctoscopic examination in all cases of rectal bleeding from whatever cause will enable us to detect a large number of those neg-

lected cases without frightening propaganda to the public. Better diagnosis on our part will instill confidence in the patient, and discovery of an early lesion so impresses the patient that the physician frequently will note in the ensuing few weeks that he examines quite a few people who turn out to be relatives or friends of the patient. This is publicity along the proper lines and should be cultivated. In our present day knowledge, wide surgical removal offers the best hope of cure. The surgeon must constantly widen the scope of operability and the operation itself, taking into account, of course, certain limitations due to the general condition of the patient who has to be considered as well as the disease.

A few figures are presented as to operability and curability when the one stage combined abdominoperineal operation was performed:

Operability. One hundred patients had been examined, 10 of whom refused any treatment whatsoever. Twenty patients of the 90 remaining were considered inoperable, 9 of whom received no treatment and 11 were given palliative measures. The number explored was 70 or 77 per cent. Thirteen of these were considered inoperable; 10 had liver involvement and in 3 fixation had occurred. The 57 remaining, or 80 per cent, were operated upon. Fifty-four had a combined, one stage operation while 3 were subjected to different operations. There were 4 operative deaths in all, or a 7.2 per cent mortality.

Curability. Statistics showed that there was a 12 per cent hospital mortality among 100 patients. Metastasis had occurred in 56 patients of this group; 46 or 52.5 per cent, are still living and 54 have since died.

SURGICAL TREATMENT OF DUPLICATIONS OF THE ALIMENTARY TRACT

Enterogenous Cysts, Enteric Cysts, or Ileum Duplex

WILLIAM E. LADD, M.D., F.A.C.S., and ROBERT E. GROSS, M.D.,
Boston, Massachusetts

DURING recent years we have treated 18 patients with cystic lesions which were situated along various parts of the alimentary canal, and here group them together as an entity, because there are certain features which are common to all of them. Inasmuch as these cysts have appeared in divers locations and have had many shapes and sizes, a confusion of terms has arisen in the literature to describe the specimens. Such structures arise from tongue to anus (Fig. 1), appear to have a common derivation, and present similar problems. Hence, they should be grouped under one generic term. We have chosen to list them as "duplications of the alimentary tract."

The names most frequently applied to these lesions are "enteric cyst," or "enterogenous cyst." However, such terms are not inclusive enough, because some of the lesions are tubular and course through the mesentery parallel to the bowel or communicating with it. Likewise, they have been called "giant diverticula" but this, again, is unsuitable, because some of them do not possess the communication with the alimenteric tube which this term suggests. "Ileum duplex" has previously been used to describe several of these specimens, but again, this does not adequately include the condition as seen in the jejunum, duodenum, stomach, or elsewhere in the gastro-intestinal tract. "Inclusion cysts" conveys the idea that some of these structures are an integral part of the intestinal wall, yet this certainly is not true in all of the cases here presented. It is, therefore, proposed that the general term, "duplication of the alimentary tract," should be substituted for all of these names, since it is all inclusive and serves to bring these various lesions together as a single entity.

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PATHOLOGY

Duplications of the alimentary tract are hollow structures which possess a muscular coat, usually of two layers, and are lined with epithelium similar to that found in some portion of the gastro-intestinal tract or colon. These lesions are always contiguous to some portion of the alimentary tube, and in all but one case they were strongly adherent to it. The type of epithelium lining the duplication does not necessarily correspond to that part of the alimentary tract to which the structure is attached. Thus, a cyst of the tongue was lined by colonic mucosa, and a cyst of the rectum was partially lined with gastric epithelium. The cystic structure may or may not communicate with the adjacent intestinal lumen. In 2 cases there was such a communication, but in the 16 remaining cases there was no opening.

An important finding is the histological fact that the muscular coats of the duplication are intimately adherent to and at times are microscopically an integral part of the muscularis of the alimentary tract (Fig. 6).

The contents of a duplication vary with the type of epithelium lining the structure, with the presence or absence of a communication with the adjacent intestine, and with the presence or absence of necrosis of the duplication wall. Thus, if there is an opening into the bowel, the duplication contents will be similar to those of the adjacent intestinal tract. In general, however, there is no communication with the intestinal lumen and the cystic struc-

TABLE I.—CASES OF DUPLICATIONS OF THE ALIMENTARY TRACT

Case no.	Age	Position of cyst	Size	Type of mucous membrane	Treatment	Result
1		Base of tongue	1 cm. in diameter	Colonic	Excision	Recovered
2	11 mos.	Right pleural cavity	4 to 5 cm. in diameter	Gastric	Attempted excision	Recovered
3	2 yrs.	Mediastinum	10 by 6 by 5 cm.	Gastric	Excision	Recovered
4	7 mos.	Right pleural cavity	8 by 5 by 4 cm.	Gastric	Excision	Dead
5	7 yrs.	Along stomach	Large as stomach itself	Necrotic	Marsupialization	Recovered
6	5 wks.	Duodenum	4.5 by 3.5 by 3.5 cm.	Duodenal	Resection, posterior gastro-enterojejunostomy	Recovered
7	6 mos.	Jejunum	22 by 6 by 6 cm.	Gastric	Mickulicz resection	Dead
8	2 wks.	Jejunum	4 cm. in diameter	Jejunal	Resection and anastomosis	Recovered
9	3 mos.	Ileum	7 by 4 by 4 cm.	Gastric	None	Dead
10	19 mos.	Terminal ileum	15.5 by 4 by 5 cm.	Columnar epithelium	Excision	Recovered
11	12 days	Terminal ileum	1.5 cm. in diameter	Ileal	Resection and anastomosis	Recovered
12	9 yrs.	Terminal ileum	1.2 cm. in diameter	?	Not yet treated*	
13	2 mos.	Terminal ileum	2 cm. in diameter	Ileal	Resection and anastomosis	Recovered
14	6 yrs.	Ileum	3 cm. in diameter	Ileal	Resection and anastomosis	Recovered
15	2 yrs.	Ileum	28 cm. long, 2 cm. in diameter	Gastric	Resection and anastomosis	Dead
16	3 mos.	Cecum	4 cm. in diameter	Colonic	Resection and anastomosis	Dead
17	2 wks.	Sigmoid	12 by 10 by 8 cm.	Ileal and colonic	Not treated	Dead
18	6 mos.	Rectum	5 by 2.5 by 2.5 cm.	Mixed	Excision, rectum repaired	Recovered

*This cyst was discovered during operation for acute appendicitis and has not yet been removed.

ture contains a clear colorless fluid of mucoid consistency. In 2 specimens the cyst had reached such size that there was pressure necrosis and sloughing of the lining membrane. Therefore, the entrapped fluid was hemorrhagic and murky-colored.

The size of the specimens is variable. It depends upon the ability of the lesion to expand into adjacent cavities or tissues before giving symptoms, and upon the presence or absence of a communication with the intestinal tube. In one case a cyst at the base of the tongue was about a centimeter in diameter, was lined by colonic mucous membrane, and was filled with a clear syrupy fluid. In 3 cases the structures were adherent to the esophagus and had ballooned out into the mediastinum and right pleural cavity. Hence, they had grown to orange or grapefruit size before attracting attention. One specimen which arose from the greater curvature of the stomach in a 6 year old girl was almost as large as the normal stomach itself. The cystic lesions appearing along the duodenum, jejunum, and ileum, usually do not become larger than a golf ball before producing symptoms. In Case 15 the structure was sausage-shaped, was 38 centimeters long and 2 centimeters in diameter, and ran along the mesenteric border of the terminal ileum. One duplication of the sigmoid was about the size of a large orange. Finally, in a 6 months' old patient, there was a cyst arising from the posterior rectum wall, which was somewhat larger than a plum.

The levels at which duplications have occurred in the present series were as follows: base of tongue, 1; esophagus, 3; stomach, 1; duodenum, 1; jejunum, 2; ileum, 7; cecum, 1; sigmoid, 1; rectum, 1.

It is important for the surgeon to recognize the pathological difference between duplications and mesenteric cysts. The latter are lymphatic in origin, have a thinner wall, and can be readily separated from adjacent viscera. This is in contrast to the duplication, which has a thicker, musuclar wall, and which can be disconnected from the intestine only with difficulty.

EMBRYOLOGY

There are many theories which attempt to explain the origin of these duplications. Those arising in the mid or terminal ileum were previously thought to be due to aberrations in the development of a Meckel's diverticulum. However, this theory is no longer tenable. Twinning of an isolated portion of the embryo has been believed by some to be the causative factor. Sequestration, or a pinching off of a group of cells from the primordial intestinal tube, might well account for the development of nearby, closely placed cysts, which finally attain all of the histological elements of the wall of an alimenteric tube. The most probable explanation is that advanced by Lewis and Thyng, who frequently found diverticula at various levels in the fetal alimenteric tracts of pigs, rabbits, cats, sheep, and man. Such outpocketings were most common in the ileum, a fact which suggests a relationship to the high incidence of duplications in the ileum. These knob-like outpockets of the intestinal wall, which are not related to Meckel's diverticula, normally regress, but the pinching off of one of these structures might well separate it from the normal intestinal wall and give rise to an adjacent duplication.

CLINICAL FINDINGS

A duplication of the alimentary tract is usually observed in children. It may be seen in later life, but the nature of the process is one which attracts attention in early years. Our youngest patient was 2 weeks of age, the oldest was 9 years.

The symptoms produced by these lesions may be grouped under 3 headings: (1) obstruction of the alimentary tract by regional external pressure; (2) pain produced by distention of the cystic structure; and (3) hemorrhage because of interference with the intestinal blood supply, leading to sloughing of the intestinal mucosa. In the lesion appearing at the base of the tongue, difficulty in swallowing was the outstanding symptom. With the cysts of the mediastinum and the right pleural cavity, there was esophageal compression and difficulty in swallowing, and there was interference with the proper expansion of the lung, which led to dyspnea. In the duplication of the stomach, in spite of the large size of the lesion, the adjacent gastric lumen was not compressed sufficiently to cause obstruction, and the patient's primary complaint was related to epigastric fullness and pain produced by tenseness in the mass. Most of the cysts of the duodenum, jejunum, and the ileum brought early signs of partial intestinal obstruction characterized by colic-like pain, vomiting, increased peristalsis, and, finally, signs related to dehydration. In the long, tube-like duplication of the terminal ileum (Case 15), the primary complaints were related to severe painless hemorrhage from the lower intestinal tract, caused by ulceration

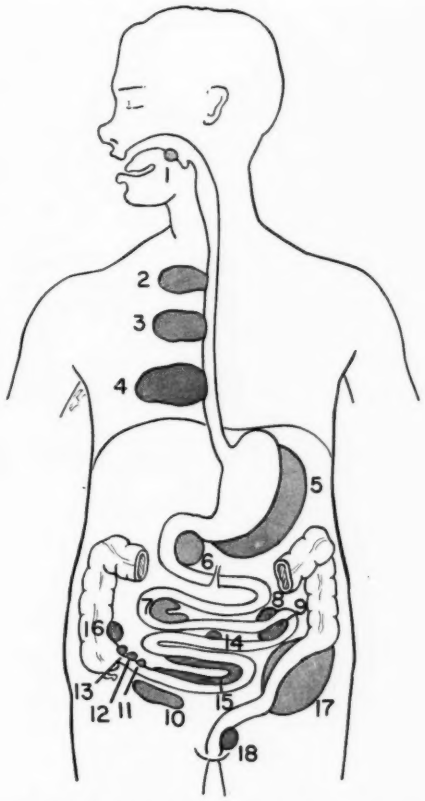

Fig. 1. Chart showing distribution of lesions in 18 cases of duplication of the alimentary tract. The number beside each lesion indicates the patient as listed in the table of cases.

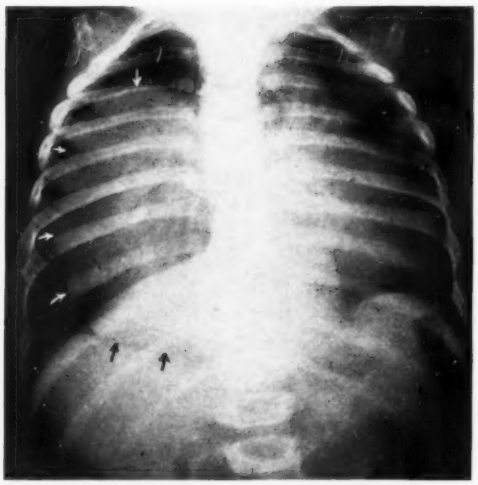

Fig. 2. Case 4. Roentgenogram of duplication of the esophagus which ballooned out into the right pleural cavity. The cystic lesion is outlined by arrows. Mediastinum and heart displaced to the patient's left side.

and sloughing of the ileal mucosa. Two small cysts of the cecum have been encountered, one of which produced partial obstruction and the other, by bulging into the cecal lumen, served as the leading point of an intussusception. Finally, the cyst of the rectal wall (Case 18) produced early encroachment on the adjacent rectal lumen, and quickly led to constipation and abdominal distention.

Physical examination often gives important evidence concerning the position of the lesion, and indeed the physical findings may strongly suggest the proper diagnosis. In a cyst at the base of the tongue the lesion can easily be palpated as a swelling below the foramen cecum. A thoracic cyst can be quickly suspected because of physical signs of dysphagia, dyspnea, and pulmonary compression. The duplication of the stomach was of such a size that it could be easily palpated, running along in the direction of the greater curvature of the stomach. This mass lacked peristaltic waves and persisted after the evacuation of the stomach with a tube and the cleansing of the transverse colon with an enema. The cysts of the duodenum, jejunum, and ileum could be palpated in practically every case. They were elastic, well rounded, usually non-tender, and except for the duodenal lesion, were quite freely movable within the abdominal cavity. In each of these cases, physical examination revealed some sign of partial intestinal obstruction. Such signs were listed as visible peristalsis, localized or general abdominal distention, and increased audible peristaltic activity. The tube-like structure along the terminal ileum in Case 15 could not be felt during examination of the abdomen, and there were no physical signs of intestinal obstruction. The only finding in this child was the presence of blood on the glove when rectal examination had been performed. The cyst of the sigmoid was freely movable, elastic, non-tender, and without signs of colonic obstruction. The cyst of the posterior rectal wall could be palpated easily with a rectal examining finger; and though the lining of the rectum was smooth, it was displaced forward so that the examining finger could not be pushed up beyond the compressed point.

ROENTGENOLOGICAL FINDINGS

Duplications in the thorax give roentgenographic findings characteristic of mediastinal neoplasms or cysts. In 1 case there was a large, well defined lesion displacing the upper lobe of the right lung. In the 2 other patients there was a large, well circumscribed, opaque mass without calcification, which apparently arose from mediastinal structures and then ballooned out into the right pleural cavity, to replace about two-thirds of the lung area in the anteroposterior chest films. The density of such a lesion is rather uniform, due to its fluid content. The uniform shadow and the absence of calcification tend to distinguish it from a dermoid or teratoma. With some of the large lesions there may be a shift of the mediastinum and heart to the other side of the thorax (Fig. 2), but it was surprising to find relatively little displacement in some of these cases. Lipiodol visualization of the bronchial tree shows marked compression of the lung on the involved side.

In the patient with a duplication of the stomach, roentgenographic studies were of considerable aid in roughly outlining the size of the lesion and in determining its position with relation to surrounding viscera. Thus, a

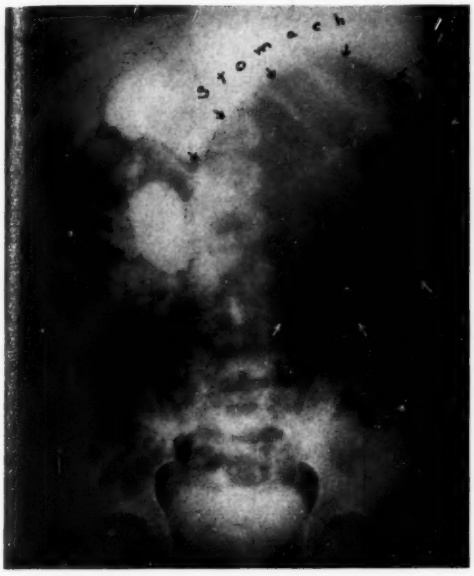

Fig. 3. Case 5. Roentgenogram of duplication of stomach showing a large mass outlined by arrows beneath the stomach. The stomach is filled with barium and is dented along its greater curvature by the mass.

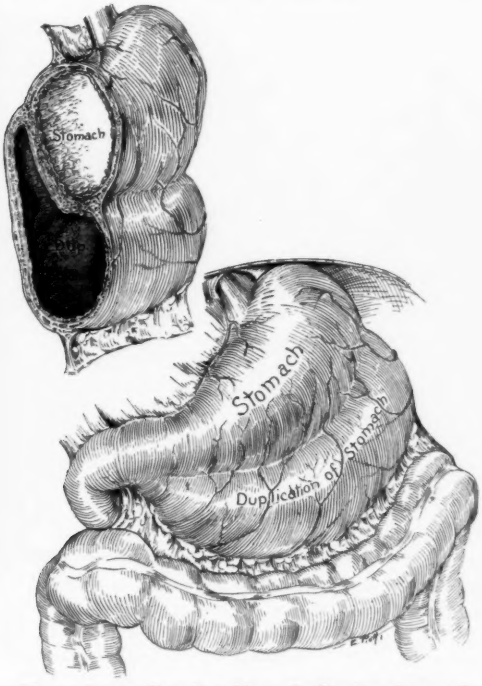

Fig. 4. Case 5. Drawing of large duplication of stomach as found at operation, with a cystic structure attached to greater curvature of stomach from the pylorus almost to the cardia. The blood vessels of right and left gastro-epiploic systems course over the duplication on their way to the gastric wall. Inset at left shows a cross section of the stomach and the duplication at the level of the gastric incision.

gastro-intestinal barium series showed a large extrinsic mass along the greater curvature of the stomach, which smoothly bulged into the gastric lumen (Fig. 3). Following this examination, a barium enema showed the mass to displace the transverse colon downward without appreciable compression of this organ.

With the duodenal cyst (Fig. 5) there was sufficient compression of the first and second portions of the duodenum to give evidence of partial obstruction at this level. The cystic lesions of the jejunum and ileum in some cases showed partial obstruction by x-ray visualization.

Usually as much could be learned from films of the abdomen in the postero-anterior and lateral direction without contrast media, as could be determined with the use of a barium gastro-intestinal series. Thus, distention of intestinal loops (Fig. 7), particularly if they are localized to one portion of the abdomen, are indicative of obstruction and may give some impression concerning the level at which the lesion exists.

The large duplication of the sigmoid (Fig. 12) showed a rounded area of rather uniform density with peripheral displacement of gas-containing viscera. A barium enema in such a case should outline the sigmoid as a flattened viscus, as it courses around the mass. In the cyst of the posterior rectal wall, roentgenographic examination was a great aid for 2 reasons: First, it gave some idea of the size and superior extent of the lesion in the lateral field (Fig. 13); second, the absence of bony defect in the lumbar and sacral vertebræ gave some assurance that the pelvic mass was not an anterior meningocele.

TREATMENT

Obviously, the treatment of this condition is one requiring surgery. Two important facts

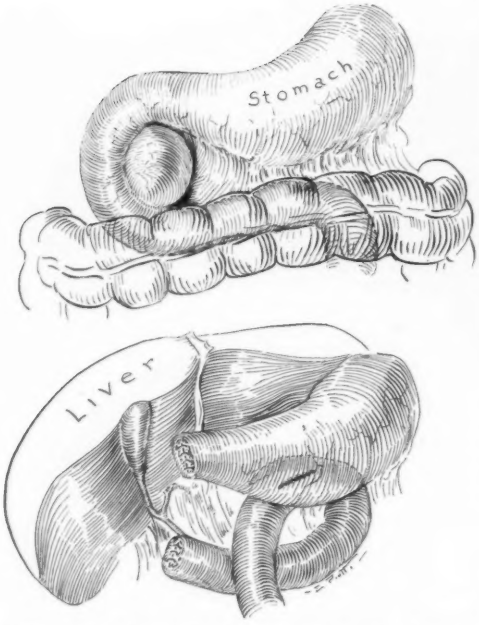

Fig. 5. Case 6. Duplication of first and second portions of duodenum as found at operation. Lesion treated by excision of cyst and partial resection of duodenum supplemented by posterior gastrojejunostomy. Patient recovered.

must again be stressed regarding the pathology of these lesions in relationship to operative procedures: First, the cystic structure and the intestine have a common wall at one point, and the two cannot be dissected apart with safety; second, the blood vessels of the contiguous alimentary tube may course over the surface of the cyst, hence attempts at local removal of the cyst may induce ischemia and necrosis of the intestine. This latter consideration is particularly important in the treatment of a lesion of the small intestine and of the sigmoid, in which the vessels from mesenteric or sigmoidal leaves spread out over the surface of the cyst. In the lesion at the base of the tongue we had no difficulty in excising the mass completely, working through the oral cavity.

The thoracic lesions have given us the greatest difficulty, from the point of view of technical procedures, particularly when they have been treated in patients who are under 1

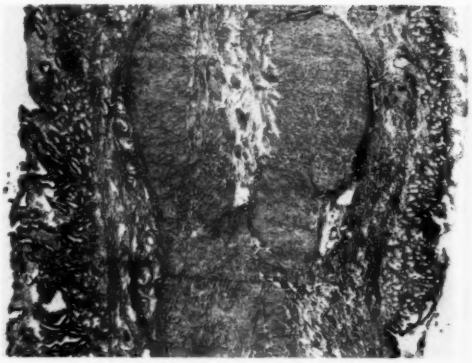

Fig. 6. Case 6. Photomicrograph of the common wall between the duodenum and the duodenal duplication. Duodenal mucosa is seen at left. The mucosa of duplication is shown at right. Between them are intermixed smooth muscle coats without a plane of cleavage. This illustrates the difficulty which would be encountered when attempting to dissect these cysts away from the adjacent intestinal wall.

year of age. We have attempted in every case to open the thorax through a posterior or posterolateral incision, to enter the pleural cavity and then free the cystic structure from the adjacent lung, a dissection which can easily be performed. However, on attempting to dissect away the cyst wall from the esophagus, the dangers of entering the esophageal lumen are high. In one of our cases the esophageal lumen was entered, and the surgical field was thereby transformed from an aseptic into a soiled one. On first consideration it would seem relatively easy to turn in the edges of the damaged esophagus, but it has been our experience that the closure thus affected heals poorly, and there is great danger of establishing an esophageopleural fistula. This possibility of injury to the esophagus must be stressed, because if the surgeon overlooks a small opening thus accidentally made, the patient will subsequently develop a fatal mediastinitis or empyema; whereas the recognition of the esophageal defect during operation allows the surgeon to make some provision for closing the defect or for treating regional infection which surely will subsequently develop. The poor results which have been obtained in these thoracic lesions, due primarily to the associated esophageal injury at time of operation, raises the possibility

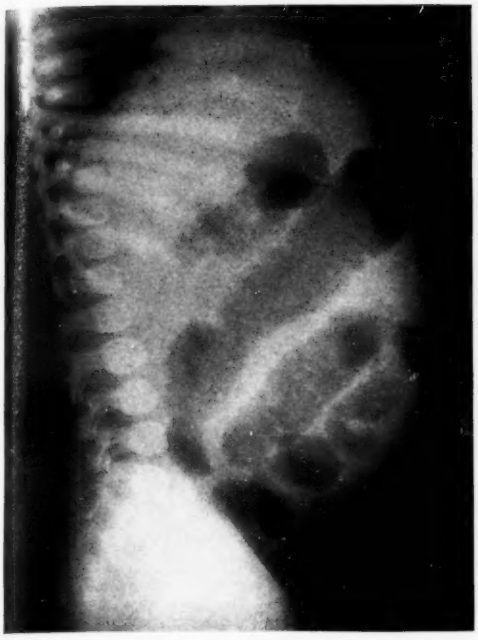

Fig. 7. Case 7. Lateral roentgenogram of abdomen showing dilated intestinal loops, accumulation of fluid between the loops, and marked abdominal distention. These findings are indicative of obstruction which at operation was found to be caused by a large duplication of the lower portion of the jejunum.

that these patients might be treated better by marsupialization of the cyst through the posterior thoracic wall, combined with subsequent destruction of the cyst lining by the use of necrobiotic agents which could be easily introduced through the fistulous opening.

The duplication of the stomach, as exemplified in Case 5, might be treated in several ways. First, a total or nearly total gastrectomy with establishment of an esophagojejunostomy would permit the removal of the cystic structure along with the stomach. However, this appears to be a rather extensive undertaking, particularly in a young individual. This risk does not seem to be justified when simpler, more satisfactory forms of treatment are available. We were fortunate enough in our case to find a cyst so distended by accumulated secretory fluid that there had been sloughing of its entire mucosal lining.

Fig. 8. Case 7. Surgical specimen of duplication of the jejunum. The intestinal tract appears at the periphery of the specimen. The sausage-shaped duplication is very adherent to the intestine on its mesenteric side and shows the impossibility of dissecting out the cyst without destroying the blood supply of the jejunum.

Therefore, by simply marsupializing this duplication onto the anterior abdominal skin, the release of all entrapped fluid allowed the walls to fall together and to coalesce. If one should not be so fortunate in having the mucous membrane thus spontaneously destroy itself, two methods of treatment are open, either by marsupialization and subsequent injection of sclerozing fluids, or by establishment of a large communication between the cyst and the stomach to permit drainage of the cyst contents into the gastric lumen.

In the patient with a cyst of the duodenal wall (Fig. 5), the first portion of the duodenum and the mass were exised *in toto*, the ends of the duodenum were inverted, and a posterior gastrojejunostomy was performed with satisfactory results.

In those duplications of a cystic nature occurring between the duodenum and cecum, we have practiced complete extirpation of the mass, along with resection of the adjacent portion of the intestine. We have adopted this policy because experience has shown that the mass cannot be enucleated without the danger of perforating the intestine or leaving it in an ischemic state. In all cases, except one, we employed a side-to-side anastomosis to re-establish the continuity of the intestinal tract, because end-to-end anastomosis of the

Fig. 9. Case 8. Photograph taken during operation showing a golf-ball sized duplication of the lower jejunum. The adjacent intestine is compressed over one surface of the cystic structure. Resection of cyst and adjacent intestine followed by lateral anastomosis with successful result.

small intestine in infants and children is technically difficult and may lead to disaster.

While it is our belief that the most satisfactory outcome will be insured by surgical excision of the mass and local resection of the adjacent intestine, mention must be made of the publication of Gardner and Hart, who treated a cystic lesion of the duodenum by a transduodenal approach and opened a large window from the duodenum into the cyst. This allowed the cyst to empty its mucoid contents continuously into the duodenum. The success of this procedure in Hart's case suggests that it might be worth trying in cases where a short operative procedure is necessary because of the poor general condition of the patient. It must be pointed out that stasis in such an outpocket from the intestine might lead to troublesome symptoms. Hence, the opening into the cyst must be adequate to insure proper drainage.

Cysts of terminal ileum or cecum may so impinge on the ileocecal valve that partial obstruction is produced. The 2 specimens which we have encountered in this region demonstrated the impossibility of excising them from the cecal wall without injury to the remaining intestine or valve. Therefore, we have again practiced local resection and establishment of an ileocolostomy.

The large cyst of the sigmoid which was discovered at autopsy demonstrated again that it would be futile to dissect the cyst from the sigmoidal loop, and that the best method

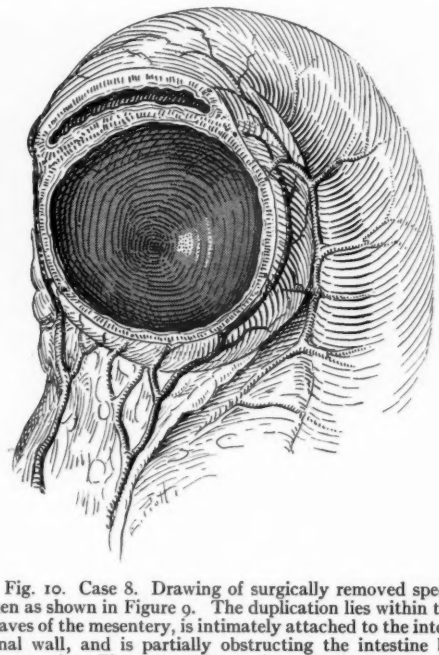

Fig. 10. Case 8. Drawing of surgically removed specimen as shown in Figure 9. The duplication lies within the leaves of the mesentery, is intimately attached to the intestinal wall, and is partially obstructing the intestine by compression. The mesenteric arteries and veins course over the surface of the cyst as they are distributed to and from the intestine.

of treatment would be excision of the mass and the adjacent gut, re-establishment of the colonic continuity, possibly combined with a temporary cecostomy or transverse colostomy as a safety valve.

The duplication of the posterior rectal wall in Case 18 (Figs. 14 and 15) was first treated by the family doctor, who intermittently relieved the rectal obstruction by aspirating the cyst through a posterior sacral approach. Fortunately, infection did not occur. Each time the cyst was aspirated it refilled in 5 or 6 days' time and again displaced the rectum forward in such a way so as to obstruct its lumen. Operation on this 6 month old baby was performed under ether anesthesia, with the child in the face-down position and the abdomen supported on a sand bag, so as to push the buttocks high up in the operative field. A curved incision, posterior to the anus, permitted displacement of the anus and anal sphincters forward. Then, by carrying the dis-

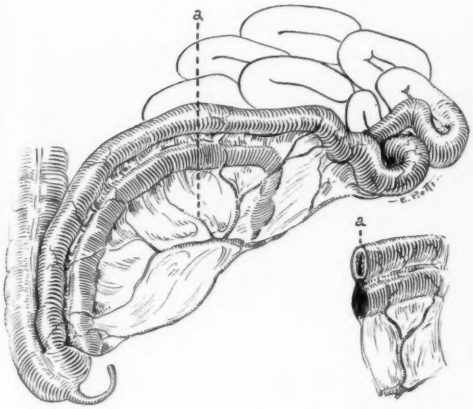

Fig. 11. Case 15. Drawing of long tubular duplication of the lower ileum Duplication 38 centimeters long. Insert *a*, shows the duplication within the leaves of the mesentery adjacent to the normal ileum.

Fig. 12. Case 17. Photograph of abdomen at autopsy showing a cystic duplication (12 by 10 by 8 centimeters) of the sigmoid in a 2 week old infant. Arrows indicate the flattened sigmoid, *1*, as it courses over the surface of the duplication, *2*.

section upward in the midline between the levator ani muscles, the hollow of the sacrum was reached, and the cyst behind the rectum was exposed. Little difficulty was encountered in dissecting the cyst along its posterior, superior, and lateral surfaces, where good lines of cleavage were obtained. However, the cyst was found to be extremely adherent to the rectal wall, and in the course of the dissection a large opening was made in the posterior portion of the rectum. The rectum was now repaired by turning it inward with 3 layers of interrupted, fine, chromic catgut sutures. A small rubber drain was led down into the hollow of the sacrum, and brought out through the skin incision. The rectal wall healed *per primam*. There was no suppuration in the perirectal spaces, and the child quickly recovered.

SUMMARY

Attention is directed to duplications of the alimentary tract. These are congenital abnormalities, presumably produced by pinching off a small bud from the gut wall with development of this segregated tissue into a cystic structure adjacent to the normal intestine. Such cystic lesions may appear at any level from the tongue to the anus. Treatment consists of complete excision of the cyst if possible, with removal in addition of the attached portion of the alimentary tract, if this is feasible. If such excision cannot be performed, a window may be cut between the cyst and adjacent intestine to establish drainage; or the cyst may be marsupialized and its lining cauterized with sclerosing agents. When operation is based on these principles, the results of the surgical procedures have been good.

CASE REPORTS[1]

CASE 5. E. L., a 7 year old girl, complained of recurring abdominal pain and vomiting for 9 months. Each attack usually lasted for 2 or 3 days and occurred at 2 or 3 week intervals. During attacks she vomited 5 or 6 times a day.

Physical examination showed the patient to be poorly nourished and somewhat pale. There was diffuse tenderness and rigidity in the abdomen which was more marked above the umbilicus. Just above the umbilicus a large ovoid mass could be felt running across the abdomen from one costal margin to the other. This was quite tender. It was smoothly rounded and definitely cystic.

Laboratory data revealed the urine to be negative. Routine blood studies were negative. There was no leucocytosis. Roentgenograms of the abdomen showed a large, soft, tissue mass filling the upper portion of the abdomen, extending more to the left.

[1]Case 3 was reported previously by Mixter and Clifford and Cases 7 and 15 were published by Hudson. Cases 1, 2, 5, 6, 10, 11, and 13 were listed in an address by Ladd.

Fig. 13. Case 18. Lateral roentgenogram of patient with a cystic duplication of the rectum. Barium in the rectum shows it to be displaced forward by a mass lying in the hollow of the sacrum.

Fig. 14. Case 18. Photograph of duplication of rectum which was surgically excised.

Gastro-intestinal roentgenograms outlined the stomach and showed it to be encroached upon and compressed by the mass (Fig. 3). A barium enema showed some downward displacement of the transverse colon by extrinsic pressure of the mass.

Under ether anesthesia, laparotomy was performed. A large, smooth, elongated cystic lesion was found adherent to and running along the greater curvature of the stomach. This cystic mass was intimately attached to the gastric wall, and though there was a slight groove between this and the stomach, there did not appear to be any plane of cleavage to permit a safe dissection of the mass away from the stomach. Furthermore, the blood vessels of the right and left gastro-epiploic systems coursed over the anterior surface of the mass and then ran up onto the gastric wall. It appeared too hazardous to attempt enucleation of the cyst, and hence marsupialization was decided upon. A considerable portion of the cyst was exteriorized by bringing this out at the central portion of the wound. After the abdomen was thus closed, the exteriorized portion of the cyst was approximately 15 centimeters in length and 5 or 6 centimeters in diameter. This presenting portion was cut off, and nearly 2 liters of watery, chocolate-colored fluid were evacuated. The internal lining of the cyst was distinctly hemorrhagic and necrotic. To insure destruction of any viable cells which might yet line the cyst, the remaining cavity was tightly packed with gauze.

The pack was removed on the sixth day. Subsequent dressings were changed frequently. The amount of discharge quickly diminished. By the time of hospital discharge, 6 weeks after operation, the wound had completely healed over. The patient has been followed for 3 years since operation, and there have been no further recurrences of her symptoms. Presumably, the great distention in the cyst brought about from secretion of fluid by the lining spontaneously destroyed the lining and by marsupialization the cyst walls were permitted to coalesce.

The excised portion of the cyst wall was examined histologically. This was fibrous, very edematous, and was infiltrated with many polymorphonuclear cells. On the inner surface there was a variable amount of fibrinoid and hemorrhagic material. The lining membrane had been entirely destroyed. Beneath the serosal covering were 2 well defined, smooth, muscular coats.

Case 6. P. S. was a 5 week old baby who was admitted because of vomiting since birth. She had been born at full term by normal delivery and weighed 8 pounds 9 ounces. On the second day she vomited blood. This was diagnosed as hemorrhagic disease of the newborn, for which she was treated by transfusions and blood given intramuscularly. During this period she had black, tarry stools. On the fifth day the symptoms of intestinal bleeding had disappeared. On the thirteenth day she was discharged from the maternity hospital weighing 7 pounds 8 ounces. The child did not do well at home in spite of the fact that she seemed to nurse well at the breast. She regurgitated a good deal and lost weight. Two days before admission to the Children's Hospital she began to vomit everything given by mouth and examination demonstrated an abdominal mass.

Physical examination on admission revealed that the baby was dehydrated and poorly nourished. Her weight was 6 pounds 8 ounces. Her throat was slightly red and there were coarse rhonchi heard in both lungs. In the midline of the abdomen, just above the umbilicus, there was a freely movable, soft, cystic mass, measuring about 4 centimeters in diameter.

Several diagnoses, including mesenteric cyst, omental cyst, and enteric cysts, were considered before operation. By exploratory laparotomy, a large enteric cyst of the upper duodenum was found (Fig. 5), which could not be dissected from the intestine. Therefore, the resection of the cyst, together with the first portion of the duodenum, was performed, followed by a posterior gastrojejunostomy. Following operation the baby's temperature fell to 95 degrees and then rose to above 103 degrees within the space of a few hours. Her condition was very precarious. A transfusion and parenteral fluids were given. A week after operation her temperature became stabilized and she took her feedings well. When she was discharged 7 weeks after admission she had gained a pound and a quarter since operation. The child has been well for 3 years since the operation.

The pathological specimen consisted of a portion of small intestine measuring 2.5 centimeters in length and 1.5 centimeters in diameter. Along the mesenteric border was attached a concave portion of a cyst wall measuring 4.5 by 3.5 centimeters in greatest diameter. The serosa of the bowel was continuous with that of the cyst. It was smooth over the bowel; however, over the cyst there were numerous small tabs of fibrous tissue.

The lining of the cyst was dark pink in color and finely injected throughout. The intestinal mucosa was pale, pinkish-gray in color, and slightly edematous. No opening between the cyst and intestine could be found.

Microscopically, the cyst had a well defined outer and inner smooth muscle coat. Lining the cyst was an epithelium similar to that of normal duodenum, except for the fact that the glands were not as deep as those of the adjacent duodenum. There were, however, numerous Brunner's glands. One of the sections had been cut from the specimen in a manner to include the wall between the cyst and the duodenum and to show the surfaces which lined these 2 structures (Fig. 6). It was quite evident that the muscular coat of the cyst intimately fused with that of the duodenum. The final diagnosis was cystic duplication of the duodenum.

Case 7. L. A. was a 6 month old female infant who was admitted to the Children's Hospital for the treatment of progressive abdominal distention and bilious vomiting of 2 weeks' duration. During this time she had been given daily enemas for constipation. For the 4 days before admission the child had been feverish.

Physical examination showed an infant who appeared chronically ill. The abdomen was markedly distended, rigid, and tympanitic except in the right lower quadrant. Here there was a palpable, firm, rounded mass about the size of a grapefruit. This mass could not be reached by rectal examination. The tumor was only slightly movable. Physical examination was otherwise negative.

Soon after admission the abdominal mass was difficult to palpate. Roentgeographic examination

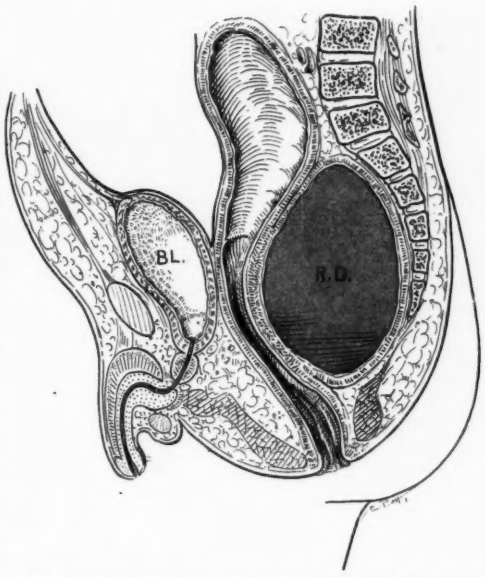

Fig. 15. Case 18. Reconstruction drawing showing the duplication anterior to the sacrum and producing partial obstruction of the rectum. Surgically treated by excision of cyst and part of posterior rectal wall. Rectum accidentally opened in excision of cyst. Suture of rectal defect followed by recovery. *Bl.*—bladder; *R.D.*—rectal duplication.

(Fig. 7) showed free fluid and gas in the peritoneal cavity, which was interpreted as being due to a ruptured viscus. Operation showed diffuse peritonitis and a large cyst attached to the jejunum. The cyst had not actually perforated, but at one point was very thinned out and necrotic. The cyst, with about 14 inches of jejunum, was resected and followed by a double-barrelled enterostomy of the Mikulicz type. The child suffered considerably from postoperative shock, but on the fourth day seemed to be in good condition. At this time it was evident that the great loss of fluid through the jejunostomy was rapidly dehydrating the child in spite of parenteral administrations of fluid. On the fifth postoperative day a small clamp was placed between the 2 loops of the jejunum. On the seventh day the wound broke open and the abdominal contents eviscerated. The wound was resutured, but the child failed to survive.

The pathological specimen consisted of a segment of small intestine and associated mesentery, measuring 45 centimeters in length (Fig. 8). Lying within the leaves of the mesentery was a thick-walled, cone-shaped, cystic mass measuring 22 centimeters in length and tapering from a large dilated end, which measured 6 centimeters in diameter, to the smaller end, which measured 2.5 centimeters in diameter. At

the larger end there were 2 constricted areas 1.5 centimeters in length with a lumen 3 millimeters in diameter. At the distal end and between the constricted areas the lumen was dilated to a diameter of 1 centimeter.

The surface of the cystic structure was extremely congested and in places there were small accumulations of yellowish-brown fibrinopurulent exudate. The wall varied from 7 to 8 millimeters in diameter. The lining was generally smooth and glistening, although extremely hemorrhagic in some areas. The color of the lining varied from pale yellowish-gray to pinkish-gray. An area of ulceration, 1 centimeter in diameter, was present in the dilated portion. The serosa over this area was dull brownish-gray and congested. The wall at this point measured approximately 1 millimeter in thickness, but there was no perforation.

Microscopically, the cyst was lined with a gastric type of mucosa. There were large open crypts, at the bases of which there were branching gastric glands containing parietal and chief cells. Areas of ulceration were present, and there was a fibrinous exudate on the surface, but the underlying submucosa presented a more marked inflammatory reaction than elsewhere. The muscularis was of two thick layers with bundles of diagonally-running, smooth-muscle fibers in addition. The serosa was edematous, congested, and infiltrated by a variable number of lymphocytes, polymorphonuclears, and macrophages. A section, including both cyst and jejunum, showed the muscularis of each closely applied to the other with only a thin layer of connective tissue.

The diagnosis was cystic duplication of the jejunum with gastric type mucosa and acute and chronic inflammation.

CASE 8. D. B. was a 2 week old male infant in whom an abdominal swelling had been noticed for 2 days. At 6 days of age the patient developed diarrhea which was first thought to be infectious in nature. On the eleventh day of life there was an onset of vomiting which persisted until hospitalization. On the twelfth day physical examination disclosed a mass in the lower abdomen.

Physical examination revealed that the patient was a well developed and nourished but somewhat dehydrated infant. The important finding was related to the presence of a smoothly rounded, slightly fluctulant, non-tender mass about 4 centimeters in diameter, which could be moved freely in the lower abdomen. This mass could be barely felt at the tip of the finger by rectal examination. The stool did not contain gross or microscopic blood.

Laparotomy was performed under ether anesthesia. At the level of the lower jejunum a cyst about 4 centimeters in diameter was found within the leaves of the mesentery immediately adjacent to the intestine. The intestine coursed over one side of the mass and was greatly compressed thereby (Fig. 9). The intestine above the mass was slightly dilated and was distinctly larger than the intestine below the lesion. The arteries and veins of the mesentery were clearly visualized as they coursed over the surface of the cyst from which they were distributed on to the intestinal wall (Fig. 10).

Realizing that this was a duplication, we made no attempt to peel the cyst from the mesentery or the intestinal wall. Resection of the mass and about 4 inches of adjacent intestine were performed. Both ends of the intestine were turned in and a side-to-side anastomosis was established. The child did well after the operation and was discharged on the twenty-ninth postoperative day.

The pathological examination showed a cyst weighing 44 grams. The intestine was so compressed by the adjacent cyst that its lumen was narrowed to 3 or 4 millimeters (Fig. 10). The peritoneal coats of the mesentery coursed up over the cyst and then continued on as the serosa of the intestine. The blood vessels of the mesentery could be seen coursing along the cyst wall from which they were distributed to the gut. When the cyst was opened, the wall was found to be 2 to 3 millimeters in thickness and the lumen contained a clear, glistening, colorless material. The gray, glistening, mucosal lining of the cyst was thrown up into folds suggesting valvulæ conniventes. Microscopic examination of the cyst lining was essentially the same as the mucosal lining of the adjacent jejunum. There was a moderate eosinophilic and neutrophilic leucocytic cell reaction in the cyst wall. There were few fibers suggesting a rudimentary muscularis mucosæ. Outside of this there was a well developed muscular coat consisting of two distinct layers. These, however, were much thinner than the muscularis of the adjacent intestine. The findings were typical of a duplication of the jejunum.

CASE 18. J. R. was a 6 month old female infant with recurring difficulty in moving her bowels since the age of 3 months. She had been treated by her family physician, who found a pelvic mass which pushed the rectum forward so as to compress it and at times almost completely obstruct it. This mass was thought to be elastic and cystic. The family physician had aspirated the cyst on several occasions by passing a needle into it through the skin of the coccygeal region. Each aspiration completely collapsed the mass and relieved the baby's symptoms of obstruction. However, the cyst always refilled in 6 to 7 days' time and would reach its previous size. Fortunately, at no time was there ever any infection or suppuration of the cyst because of these needlings.

Physical examination revealed the patient to be a well developed and nourished child with marked abdominal distention. Rectal examination disclosed a mass pressing the rectum from behind forward as previously described. This mass was the size of a plum and appeared to fill the hollow of the sacrum. Because of the possibility of an anterior meningocele, roentgenographic examination was performed, which showed no defect in the bone of the lumbar or sacral spine. These findings tended to exclude the possibility of meningocele. A barium enema examination showed a marked anterior displacement of the rectum (Fig. 13).

Under ether anesthesia the child was placed face downward with the body raised by placing the abdomen over a sand bag. A curved incision about 2½ inches in length was made posterior to the anus and was deepened to permit forward displacement of the anus and anal sphincter. Thus, by dissecting upward between the levator ani muscles, the hollow of the sacrum was reached and a smoothly rounded oblong cyst was encountered (Fig. 15). This could be easily dissected away from the sacrum and its lateral attachments. On carrying the dissection forward, the mass was found to be very adherent to the rectal wall, and in spite of extreme care in cutting away the structure the rectum was opened for a distance of about 1 inch. After the cyst was thus removed, the rectal wall was repaired with 3 layers of interrupted fine chromic catgut sutures.

After operation the rectum was kept empty with occasional irrigations. The cutaneous wound was frequently dressed in order to keep it as clean as possible. No suppuration occurred in the perirectal fossa, and the skin healed *per primam*. The child recovered completely and was discharged on the tenth postoperative day. There was no rectal fistula. The child has been followed for 1½ years since this operative procedure.

The pathological specimen was an ovoid cyst measuring 5 centimeters in length and 2.5 centimeters in diameter (Fig. 14). When the specimen was opened it was found to be filled with clear, yellowish fluid. The wall of the cyst was approximately 2 millimeters in thickness. The internal surface was smooth, gray, and had a velvety appearance suggesting that the lining was composed of a mucous membrane. Histological examination showed the mucosal lining to consist of many types of epithelial surfaces varying from the simple columnar, both with and without goblet cells, to stratified squamous and ciliated epithelial cells. A large part of the mucosa showed shallow crypt formations of the epithelial glands which contained chief and parietal gastric cells. The change from one type of mucosa to another was abrupt and without transition. The submucosa was composed of a loosely arranged areolar tissue surrounded by a moderate number of plasma cells, lymphocytes, and an occasional polymorphonuclearcyte. The muscularis was composed of smooth muscle fibers and was arranged in a heavy inner circular and a somewhat lighter outer longitudinal layer.

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THE CONTROL OF HEMORRHAGIC TENDENCIES

WALTMAN WALTERS, M.D., Sc.D., F.A.C.S., Rochester, Minnesota

A DISCUSSION of hemorrhagic tendencies of surgical patients might be grouped as follows: (1) bleeding from lesions of the gastro-intestinal tract; (2) tendency to bleed exhibited by patients who have lesions of the biliary tract and jaundice; and (3) tendency to bleed exhibited by patients who have certain blood dyscrasias, such as purpura hæmorrhagica, hemophilia, and pseudohemophilia.

GASTRO-INTESTINAL BLEEDING

Duodenal ulcer. In a study of 668 cases of gastro-intestinal bleeding by Rivers and Wilbur (32, 33) it was found that in 60 per cent of the cases a blood vessel in a duodenal ulcer was responsible for the condition. Although in some cases bleeding may be caused by a duodenal ulcer on the anterior wall of the duodenum, the most frequent site in which bleeding occurs in the duodenum is the posterior wall of this structure. Ulceration usually extends into one of the branches of the gastro-duodenal artery. It is the patient who has a bleeding ulcer of the posterior duodenal wall who may have a fatal hemorrhage, and the condition is more likely to afflict those patients in or beyond the fifth decade of life. Although the incidence of fatal hemorrhage resulting from an ulcer of the posterior duodenal wall has been variously estimated to be from 3 to 8 per cent, I believe that if a determination were made of the mortality rate arising from hemorrhage in that group of patients who are brought into the hospital during the phase of active, serious bleeding, the mortality rate would be much higher. This is a point I wish to emphasize, for I believe that too often patients having a chronic bleeding duodenal ulcer may be denied the opportunity of undergoing surgical procedures which can be performed in the non-hemorrhagic stage at a low risk. In a paper covering this subject, Finsterer emphasized that in his series of cases the incidence of fatal hemorrhage among patients, who bled seriously from duodenal ulcer, and who were not operated upon, varied from 50 to 30 per cent.

At The Mayo Clinic, in the treatment of the patient who has a bleeding duodenal ulcer and who is operated upon in the remissive stage of the hemorrhage, we like to remove the duodenal ulcer and, provided a sufficient portion of the duodenum remains to close accurately, to perform partial gastrectomy if the condition of the patient permits. On many occasions, however, in which the ulcer is too large to warrant removal, gastro-enterostomy has healed the duodenal ulcer and hemorrhage has not recurred. While attending the meeting of the International Society of Surgery last year at Brussels, and in subsequent visits to several of the larger surgical clinics in Central Europe and Scandinavia, I gained the impression that there was an increasing tendency to regard the patient experiencing serious bleeding from duodenal ulcer as an emergency patient, comparable to the patient who has bleeding in any other part of the body. When operation was performed for such patients, control of the bleeding was the initial objective and the operation was performed in the easiest and safest way possible. Frequently, all that was necessary was to open the duodenum and suture-ligate the bleeding vessel.

Gastric ulcer. The bleeding gastric ulcer is always perforating in nature and extends into the gastrohepatic omentum. Such a lesion, in my opinion, always requires surgical treatment, and the best method of removal is partial gastrectomy.

Benign tumors of the stomach. Benign tumors of the stomach, such as adenomyomatous polyps, fibromyomas, neurofibromas, and leiomyomas, occur with greater frequency than might be expected. Their incidence varies from 3 to 5 per cent of all gastric lesions. These tumors, even though they are small, frequently may bleed so constantly that marked secondary anemia develops. Usually,

From the Division of Surgery, The Mayo Clinic.

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gastric symptoms are absent unless the polyp has a pedicle which is long enough to obstruct the pylorus. The only symptoms of which many patients complain are those associated with anemia, such as weakness, dizziness, and the like. Not only do these benign lesions bleed, but adenomyomatous polyps not infrequently exhibit malignant degenerative changes in their periphery. Leiomyomas may degenerate and metastasize to the liver, as described by Sworn and Cooper. Such lesions, of course, require surgical treatment and should be removed. Usually all that will be necessary is excision of that portion of the stomach which contains the tumor. If degenerative or malignant cells are found on immediate frozen-section study—a procedure that should be an essential part of the examination—partial gastrectomy should be performed immediately. In an occasional case, there are certain types of medullary gastric carcinoma from which constant bleeding will produce anemia to the extent that when the patient is examined the anemia may be thought to be primary in type. Therefore, unless the examiner is aware of the possibility that a silent benign or malignant lesion of the stomach or colon may be responsible, and unless roentgenological and enteroscopic examination is made of the stomach and colon to eliminate the presence of such lesions, they may be overlooked and eventually may grow to such a large size, particularly if they are malignant, as to become almost inoperable before presenting associated gastro-intestinal symptoms. The following case is one in point:

CASE 1. A man, aged 57 years, had been treated elsewhere for 4 months for what had been called "anemia." Although there was some temporary response to hepatic therapy, with recurrence of the anemia and the appearance of symptoms of abdominal fullness after meals, a roentgenological examination of the stomach revealed an extensive malignant lesion of doubtful operability (Fig. 1 a and b). At operation an extensive carcinoma of the stomach, grade 3 (Broders' index), was found and subtotal gastrectomy was performed. No glandular involvement was found. The patient recovered from the operation and was living 2 years later when he was last heard from.

BLEEDING LESIONS OF THE COLON

Next to the stomach and the esophagus (varices), the most frequent site of bleeding gastro-intestinal lesions is the colon. The frequency with which a carcinoma of the cecum may produce anemia without the presence of other symptoms is well known to everyone, and yet not infrequently, because of the paucity of symptoms referable to the colon, the possibility that a patient who has anemia may also have a bleeding cecal carcinoma may escape attention. As in the stomach, so in the colon, single and multiple polyps which bleed may be present. In the colon, lesions have an even greater tendency to be malignant than they do in the stomach. Indeed, Dixon believes that in all such polyps malignant cells can be found. The corollary of this belief is that such polyps should be removed. Some of them, fortunately, situated in the rectum and in the sigmoid flexure of the colon, can be visualized through the proctoscope and can be destroyed by electrocoagulation.

MECKEL'S DIVERTICULUM

Although the incidence of Meckel's diverticulum is only about 2 per cent, the possibility that an ulcer in such a diverticulum may be the cause of silent gastro-intestinal bleeding, particularly among young adults, must always be borne in mind. Numerous instances of malignant lesions of Meckel's diverticulum have been reported (28). I have operated on 2 patients who had sarcoma in a Meckel's diverticulum; for both of these patients silent intestinal bleeding and anemia were the outstanding symptoms. In one of the patients, perforation of the lesion to the posterior parietal peritoneum was identified by roentgenological examination of the small intestine after the patient had ingested barium (Fig. 2).

HEMORRHAGIC TENDENCY IN PRESENCE OF BILIARY TRACT AND LIVER LESIONS

Recognition of the factors contributing to the hemorrhagic tendency of patients who have obstructive jaundice and the development of newer methods of control should be emphasized.

The tendency of jaundiced patients to bleed has been well known for many years. Prior to 1919 bleeding was present in a high percentage of those jaundiced patients who failed to recover from their operation on the biliary tract.

In 1921, I suggested a method of pre-operative preparation of jaundiced patients which consisted of the intravenous injection of calcium chloride to combat the hemorrhagic tendency and the intravenous injection of solutions of glucose to compensate for malfunction of the liver (39). In addition, the patient was placed on a high carbohydrate diet and it was suggested that the patient's fluid intake be increased to 3,000 to 4,000 cubic centimeters daily. To deeply jaundiced patients preoperative transfusions of blood were given. Abundant experimental and clinical data supporting the thesis of this method of improving the condition of the jaundiced patient are available in the research work of Mann and Magath on the effects of total hepatectomy, and the effectiveness of calcium chloride as an aid to hasten coagulation of the blood has been demonstrated by Wright, and Lee and Vincent.

As a result of the aforementioned measures and a better understanding of the problem of the jaundiced patients, as well as the institution of improved surgical methods, and the recognition of the proper time for the institution of surgical procedures among jaundiced patients, the mortality rate in operations upon jaundiced patients at The Mayo Clinic decreased progressively to the point where in 1936 only 2 cases of fatal hemorrhage in 209 jaundiced patients occurred. In 1937, 181 jaundiced patients were operated upon with 7 deaths due to hemorrhage. In 1938, in 194 jaundiced patients operated upon there were 2 cases of fatal hemorrhage.

In 1935, Quick, Stanley-Brown, and Bancroft showed that a definite relationship existed between a deficiency in prothrombin and hemorrhagic diathesis in jaundice, and they cited evidence to prove that in the presence of biliary obstruction the only substance lacking for the proper coagulation of the blood is prothrombin and that fibrinogen, calcium, and thromboplastin are all present in normal quantities in the blood of jaundiced patients.

About this same time Hawkins and Brinkhous, studying the effect of complete biliary fistulas in dogs, found a deficiency of prothrombin in the blood. They were able to correct the deficiency of prothrombin occurring among such animals by feeding bile and emphasized, therefore, the necessity of bile being present in and absorbed from the intestine.

Earlier studies by Dam and his co-workers (10-14) demonstrated that internal, subcutaneous, and intramuscular hemorrhages developed in chicks fed on a diet deficient in certain fat-soluble compounds. This hemorrhagic tendency is, as Dam first indicated (11, 12), promptly cured by administering a substance obtained from hog-liver fat and from alfalfa, which substance was described as the "coagulation vitamin" or "vitamin K."

Thus, there are two factors, the presence of bile in the bowel and a hypothetical fat-soluble vitamin, which are known to be of importance in maintaining normal concentration of prothrombin in the blood. Among patients who have obstructive jaundice bile acids are excluded from the intestine and, in addition, if the obstruction is of an extreme degree, damage to the liver may occur which will be sufficient to produce a deficiency in prothrombin.

The early clinical application of this knowledge concerning vitamin K was begun independently in the United States by Warner, Brinkhous and Smith at the University of Iowa, and by Butt, Snell, and Osterberg (7) at The Mayo Clinic. In Europe it was begun by Dam and Glavind in Copenhagen.

During the past 2 years practically all patients encountered at The Mayo Clinic, who had obstructive jaundice and who were operated upon, received vitamin K and bile salts prior to surgical treatment.

For purposes of routine pre-operative treatment, jaundiced patients are divided into 3 groups: (1) those who have a normal prothrombin clotting time; (2) those who have a prolonged prothrombin clotting time but not active bleeding; and (3) those who have a prolonged prothrombin clotting time and active bleeding.

Those jaundiced patients of the first group who have a normal prothrombin clotting time, nevertheless, receive prophylactic treatment for from 2 to 5 days before surgical intervention is undertaken. From 2 to 6 gelatin capsules, each capsule containing approximately 200 milligrams of alfalfa concentrate, together with from 1 to 4 grams of animal bile salts,

seem to constitute an adequate daily dose. Almost any type of animal bile salts can be used, but we have preferred water-soluble bile salts, particularly in those instances wherein concentrates of vitamin K must be administered by means of a duodenal tube or T tube. Human bile obtained from a biliary fistula or a T tube as previously described by Butt, Snell, and Osterberg (7) or lyophilized bile as described by Johnston may also be employed.

The condition of patients having jaundice who have an elevated prothrombin clotting time constitutes a potential or real emergency and has been treated as such. Most patients having a prothrombin clotting time of from 30 to 45 seconds will respond well to the plan of prophylactic treatment previously mentioned; but if the prothrombin clotting time is longer than 45 or 50 seconds, it has been thought advisable to administer concentrates of the vitamin together with bile salts, either by duodenal tube or after operation through a T tube. In such instances, from 2 to 4 grams of a water-soluble bile salt is dissolved in from 250 to 500 cubic centimeters of warm physiological solution of sodium chloride or tap water; to this is added from 1 to 2 grams of the concentrate of alfalfa containing vitamin K. The mixture is shaken thoroughly and is administered slowly in from 30 to 60 minutes by the drip method; care is taken to keep the solution warm and well mixed. One such dose, as a rule, will bring the prothrombin clotting time to a normal value. In the exceptional instance it has been necessary to repeat this procedure one or more times. When large or repeated doses are used, the prothrombin clotting time usually decreases within 6 to 12 hours.

The problem of treatment of patients who are actively bleeding is difficult. Clotted blood must be removed by lavage before adequate absorption of the vitamin can occur, and not infrequently gastric lavage and irrigation of drainage tubes leading from the biliary tract are required. A transfusion of blood often is necessary to aid in combating the shock produced by hemorrhage and to provide a temporary supply of prothrombin; a transfusion will, as a rule, control bleeding only so long as the added supply of prothrombin lasts, a matter of from 6 to 12 hours. Rhoads and Panzer suggested that "bank blood" is low in prothrombin and is, therefore, of little value in controlling hemorrhage in these cases. Treatment with the vitamin concentrate and bile salts is carried out in the meantime as described in the preceding paragraph and repeated as necessary.

The administration of capsules containing vitamin K and bile salts to some patients following operation was difficult, but in these cases as well as those in which it was essential that large quantities of the vitamin K be absorbed as rapidly as possible, the vitamin was administered directly into the duodenum through a tube. Hence, to obviate such a procedure, various methods were tried for the parenteral administration of vitamin K. At first vitamin K was mixed with an oil substance, such as peanut oil, and was injected intramuscularly. But in these instances it was apparent that it required several days for any noticeable decrease in the concentration of prothrombin to appear, and in addition, the region of painful induration at the site of the injection was objectionable to the patient.

Almquist and Klose recently reported that phthiocol (2-methyl-3-hydroxy-1, 4-naphthoquinone) possesses physical and chemical properties similar to pure vitamin K. Phthiocol was first isolated in 1933 by Anderson and Newman (3, 4) from the pigment of Mycobacterium tuberculosis; its synthesis was announced in 1934 (27). It has been shown by Almquist and Klose (2) that the antihemorrhagic activity of phthiocol lies between that of methyl naphthoquinone and hydroxy naphthoquinone. Their study indicated that the methyl group is functionally important, whereas the hydroxyl group seems to reduce activity. They concluded that the activity of phthiocol is lower than that of the more complex form of vitamin K existing in alfalfa, and Ansbacher and Fernholz expressed a similar opinion.

Recently, Thayer and his associates, MacCorquodale and his associates, and Fieser and his co-workers, have all reported tentative structural formulas for vitamins K_1 and K_2.

Within a few months pure synthetic vitamin K probably will be available and, judging from present work, the one possible assurance

is as first suggested by Doisy (6) and his associates, that a quinone structure will be found present.

Butt, Snell, and Osterberg (8) recently reported the clinical results in the treatment of 10 patients exhibiting hypoprothrombinemia. Phthiocol was administered to these patients. Nine of the 10 patients received either 25 or 50 milligrams of the material intravenously; 1 patient ingested 100 milligrams by mouth, together with 2 grams of bile salts. Following the administration of phthiocol, there was a decrease in the elevated prothrombin clotting time for each of the 10 patients. The usual dosage was 50 milligrams in 250 cubic centimeters of sterile physiological saline. The clotting time for each of the 10 patients receiving phthiocol was reduced to normal. One patient had been bleeding; in this instance the hemorrhage was controlled. No untoward reactions were observed.

Snell and Butt recently reported the results of studies on naphthoquinone presenting antihemorrhagic activity.

While the work of Butt, Snell, and Osterberg was in progress, Smith, Ziffren, Owen, and Hoffman reported a case of obstructive jaundice in which the administration of phthiocol was followed by an elevation of the concentration of plasma prothrombin.

Clark, Dixon, Butt, and Snell have recently reported a series of 8 cases in which diseases of the gastro-intestinal tract prevented the absorption of sufficient quantities of bile salts and vitamin K and spontaneous hemorrhage ensued. In 4 of these cases in which prothrombin studies were made, elevation in the prothrombin clotting time was noted. In these cases the administration of vitamin K and bile salts reduced the prolonged prothrombin clotting time to normal.

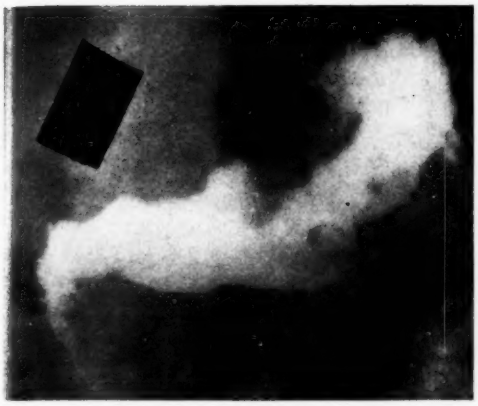
It would appear justifiable to conclude that 4 basic factors seem to be necessary in the prevention and control of a deficiency in vitamin K: (1) the presence of bile of normal composition in the intestinal tract; (2) a liver which is physiologically capable of utilizing the vitamin; (3) a diet containing the vitamin itself or material from which it can be formed; and (4) a normal absorptive surface in the small intestine.

Bleeding esophageal varices. Bleeding from esophageal varices occurs as a complication of biliary cirrhosis. Such bleeding is usually sudden in onset and without warning and blood literally gushes from the patient's mouth. Such a hemorrhage, occurring in such sudden and unexpected fashion, is almost pathognomonic of ruptured esophageal varices secondary to cirrhosis of the liver. Not infrequently immediate transfusions of blood are necessary to replace the loss of blood. Later, when the patient has recovered from the bleeding, studies of hepatic function by means of the bromsulfalein test will show considerable retention of dye in the blood and when the patient's condition permits, the diagnosis frequently can be verified by roentgenological examination of the esophagus (Fig. 3).

The surgical treatment of bleeding esophageal varices which is worthy of consideration is ligation of the left coronary vein which lies in the gastrohepatic omentum. This treatment was suggested in 1929 by Walters, Rowntree, and McIndoe (40), and it can be accomplished readily and without too great a risk by sectioning the gastrohepatic omentum as in the ligation of the gastric artery and vein in the performance of partial gastrectomy, through which the branches of the left coronary vein go to the esophagus where they anastomose with branches of the internal mammary vein. In several instances this procedure has been performed; in others, splenectomy has been performed for the purpose of decreasing the amount of blood which ordinarily passes from the spleen into the portal vein (Fig. 4). Such a procedure also tends to decrease the amount of venous blood flowing through the esophageal varices from the venous tributaries between the splenic and gastric veins. Striking results have been obtained in several cases in which these procedures have been employed at the clinic, particularly in that group of cases in which cirrhosis of the liver was a part of Banti's disease.

HEMOPHILIA AND PSEUDOHEMOPHILIA

Although hemophilia and pseudohemophilia may be present among patients who have surgical lesions, the infrequency with which these 2 conditions are encountered at The Mayo



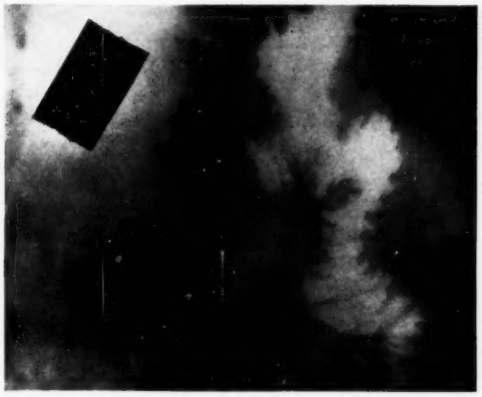


Fig. 1. a, left, Pre-operative roentgenogram of stomach showing extensive lesion in the upper third portion. This patient had been treated elsewhere for anemia for 4 months before the roentgenogram was made; b, postoperative roentgenogram following subtotal gastrectomy for carcinoma of the stomach.

Clinic is emphasized by the fact that usually less than 4 hemophiliac patients are encountered each year; approximately the same number who have pseudohemophilia are encountered at the clinic. In commenting on the diagnosis of, and the differential diagnosis between hemophilia and pseudohemophilia, my colleague, Dr. Charles H. Watkins, writes as follows:

"Hemophilia is usually readily diagnosed by the characteristic family history of hemorrhagic tendency confined to the male and transmitted by the female members of the family, by a history of frequent articular hemorrhages, prolonged hemorrhage from minor lacerations or following minor surgical procedures as dental extraction and tonsillectomy, and by absence of petechial hemorrhage.

"The laboratory finding that is most characteristic is prolongation of the clotting time of the venous blood. The (Howell) prothrombin time is generally abnormally lengthened whereas the thrombocyte count is usually normal or slightly elevated, the bleeding time is within normal limits or slightly prolonged and the clot retracts if a clot is eventually formed. Examination of a stained blood smear shows no diagnostic change; there may be a secondary type of anemia, with increased regeneration of erythrocytes, and in cases of severe hemorrhage some immaturity of the myeloid cells may be present (Table I).

"The literature contains reports of conditions similar to, if not identical with, hemophilia which affected females. There is usually a familial tendency toward hemorrhage and the laboratory findings are those associated with a true hemophilia and in addition there is usually a slight to moderate decrease in the thrombocyte count. In most of these cases there has been no evidence of male hemophilia. Most authors regard this condition as female hemophilia, but do not feel that this disease is the same as male hemophilia.

"Pseudohemophilia has been recognized for many years and more recently has been seen with increasing frequency. The condition affects both males and females and may be transmitted by either sex directly to sons and daughters. The features are recurrent hemorrhages from mucous membranes, uterus or gastro-intestinal tract. Hemorrhage may be mild or severe; it occasionally may prove fatal but usually decreases (in severity) with advancing age. Purpura is not common. Laboratory findings consist of prolonged bleeding time, normal coagulating time and normal or high thrombocyte count. The prothrombin time and clot retraction time are usually normal but they may be prolonged and may vary considerably in the same case from time to time. It is probable that many cases grouped under this heading can be more definitely placed under specific types of blood dyscrasias with future research and greater understanding of the details of the mechanism of blood coagulation.

"The treatment of hemophilia is often most discouraging. At present transfusion offers the most encouragement in all cases of serious or moderately serious hemorrhage. Local application of coagulating snake venom (that of the fer-de-lance or of Russell's viper) is of some value in control of localized hemorrhage, particularly application to the tooth socket after the extraction of a tooth or when the venom is applied directly to the bleeding lesion. In 1936, Timperley, Naish and Clark by the use of an extract of egg white were able to reduce the coagulation time and control hemorrhage in cases of hemophilia when the material was given intramuscularly or intravenously. They emphasized that this sub-

Fig. 2. Roentgenogram showing crater deformity of Meckel's diverticulum.

stance is not a cure for hemophilia as it merely controls hemorrhage and repeated injections of adequate amounts are required to do this.

"'Sango-stop,' which consists principally of pectin, has been used with some success in the control of hemorrhage by Gohrbandt. The material may be used locally or given intramuscularly. In my experience this material had no apparent effect in controlling the hemorrhage during an acute exacerbation in two cases of hemophilia.

"Patek and Taylor observed that cell-free normal plasma contained a substance which shortened the coagulation time of the blood in hemophilia. They have precipitated a globulin from normal plasma which when suspended in saline solution was as effective as whole plasma in reducing the coagulation time. This same effect could not be obtained by the equivalent material from hemophilia plasma."

The value of this substance was emphasized recently in a case in which operation was performed by Harrington on a patient who had unsuspected pseudohemophilia. This patient, after an operation of radical amputation of the breast, had continuous bleeding from all raw surfaces, a bleeding which was unaffected by transfusions of blood but which was controlled immediately by the administration of plasma as previously described.

Fig. 3. Roentgenogram of bleeding esophageal varices. Inset, gastroscopic appearance of varices.

"The use of various ovarian substances," Dr. Watkins continued, "has not been proved of much clinical value although much investigative work has been and is still being carried out along this line. There is, however, evidence that a placental extract may produce a reduction in the coagulation time. It is hoped that in the near future, as more research is carried out, some of these substances will become available but at present the most satisfactory and generally obtainable treatment is the local application of coagulating snake venom and repeated transfusion of blood."

PURPURA HÆMORRHAGICA

"Purpura hæmorrhagica, or essential thrombocytopenia," according to Dr. Watkins, "is a disease characterized by hemorrhagic phenomena and by a marked reduction of the number of platelets in the circulating blood. . . . The chronic form of the disease (which is the most frequent and is of the most surgical significance) is characterized by cyclic periods of hemorrhage and spontaneous remissions, in the course of which there is complete freedom from symptoms. . . . Usually, in time, these cyclic periods of hemorrhage become more frequent and the hemorrhage becomes more severe than before. . . ."

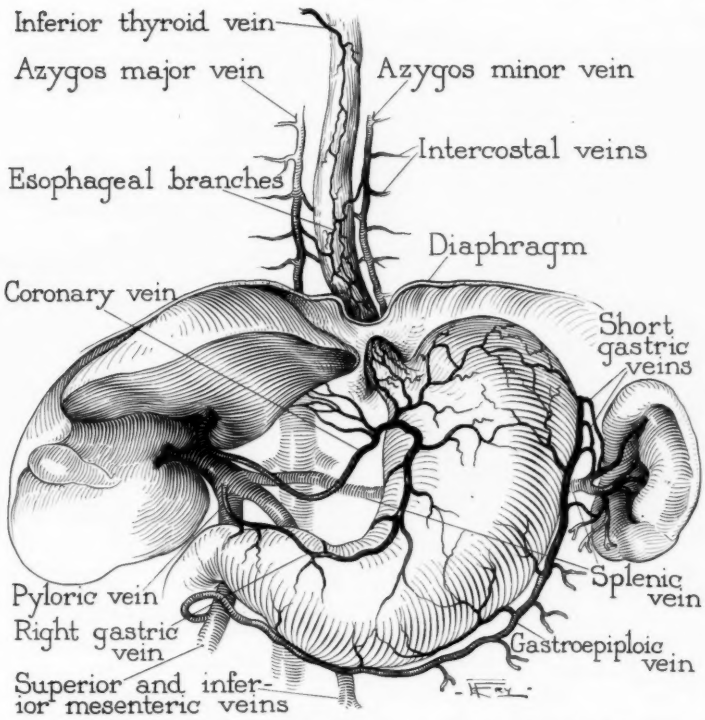


Fig. 4. Drawing showing position of left coronary vein in the gastrohepatic omentum and the relationship of the circulation of the spleen to the stomach and liver.

The laboratory observations show a reduction in the platelet count to 50,000 per cubic millimeter of blood or less. Although there is a prolongation of the bleeding time, the coagulation time of venous blood is usually normal.

The surgical treatment of chronic purpura hæmorrhagica is removal of the spleen. Removal of the spleen of patients having purpura hæmorrhagica is followed by immediate increase in platelets to normal and a decrease in and usually a cessation of the hemorrhagic episodes. In cases in which the disease is mild transfusions of blood often control the hemorrhagic tendency.

Numerous other purpuric phenomena may be confused with essential thrombocytopenic purpura, according to Watkins. Among these are the so called allergic types of purpura in which the patient frequently gives a definite history leading to identification of the precipitating allergic factor and the condition reappears when the patient is exposed again to this factor. Some chemical substances, particularly those that have a tendency to damage the bone marrow, such as arsenic and benzol derivatives, may cause purpura.

Moccasin venom and large doses of vitamin C have been used with some success. These substances are worthy of trial, but if there is no improvement, splenectomy should be performed preferably and with greater safety during the period of remission.

APLASTIC ANEMIA AND ACUTE LEUCEMIA

Although aplastic anemia and acute leucemia are diseases in which the hemorrhagic tendency plays a rôle, their occurrence is very infrequent in surgical patients and treatment consists of the palliative administration of blood transfusions.

TABLE I.—FEATURES OF COAGULATION IN HEMORRHAGIC DISEASES: DIFFERENTIAL DIAGNOSIS*

Characteristics	Hemophilia	Purpura hæmorrhagica	Aplastic anemia	Acute leucemia
Leucocyte count, total	Normal	Increased or normal	Progressively decreased	Normal, increased or decreased
Leucocyte count, differential	Normal	Normal distribution; normal cells	Relative lymphocytosis	Immature cells, especially stem cells
Signs of regeneration of erythrocytes	Normal	Reticulocyte count usually increased; polychromatophilia and anisocytosis	Reticulocyte count low; polychromatophilia and anisocytosis usually absent	Usually normal
Platelet count	Normal	Decreased	Decreased	Increased, normal, or decreased
Bleeding time	Normal or slightly prolonged	Prolonged	Prolonged	Normal or prolonged
Coagulation time, venous blood	Prolonged	Normal	Normal or prolonged	Normal or prolonged
Retractility of clot	Normal; reclotting phenomenon	Delayed or absent	Normal, delayed or absent	Normal, delayed or absent
Prothrombin time	Prolonged	Normal or prolonged	Normal or prolonged	May be prolonged
Tourniquet test	Negative	Usually positive	Frequently positive	May be positive
Heredity	Positive, occurs in males, transmitted by females	Little significance	No significance	No significance
Joint hemorrhages	Common	Rare	Rare	Rare
Petechiæ and purpura	Rare	Common	Common	Not uncommon

*Table prepared by H. Z. Giffin, M.D., and C. H. Watkins, M.D.

SUMMARY

The most frequent cause of gastro-intestinal bleeding is an ulcer of the posterior duodenal wall which perforates into the pancreas and erodes one of the branches of the gastroduodenal artery. Approximately two-thirds of the patients who have duodenal ulcer do not have hemorrhages as a result of it. If, therefore, one were to include this larger series of cases in a study undertaken to determine the incidence of fatal hemorrhage among patients having chronic duodenal ulcer, the incidence would appear to be rather low. On the other hand, if one were to study the incidence of fatal hemorrhage among the 33 per cent of patients who do bleed, the incidence would be found to be much higher, varying from 14 per cent (Holman) to 40 per cent (Finsterer). The corollary of this is that the condition of the patient who has an acutely bleeding duodenal ulcer should be regarded as a surgical emergency and should be treated accordingly; when necessary the hemorrhage should be controlled by opening the duodenum and suture-ligating the gastroduodenal artery, provided the condition of the patient permits.

Bleeding tumors of the stomach and colon, both benign and malignant, may cause continuous bleeding without gastro-intestinal symptoms. The presence of the anemia and its associated symptoms of weakness, dizziness, and faintness may be the only symptoms present.

Intestinal bleeding may occur as the result of an ulcer or a tumor of a Meckel's diverticulum.

It has been shown that there is a definite relationship between the concentration of prothrombin in the blood and the hemorrhagic tendency of jaundiced patients. The hemorrhagic tendency is the result of exclusion of bile acids from the intestinal tract and the absence of a hypothetical fat-soluble vitamin described as "the coagulation vitamin" or "vitamin K." In the presence of such a tendency the prothrombin clotting time of the blood may be prolonged. By means of the oral administration of bile salts and vitamin K, a decrease in the prothrombin clotting time of the blood is obtained and bleeding ceases if it has been present. Almquist and Klose recently reported that phthiocol, a naphtho-

quinone, presented physical and chemical properties similar to those of pure vitamin K. Butt, Snell, and Osterberg recently reported the clinical results obtained in the treatment with phthiocol of 10 patients exhibiting hypoprothrombinemia. Each of the patients was thereby afforded a decrease in the elevated prothrombin time. Nine of the patients did not bleed, and one patient who had been bleeding ceased to bleed. Phthiocol can be administered intravenously by using 50 milligrams in 250 cubic centimeters of sterile physiological saline solution.

Bleeding from esophageal varices secondary to cirrhosis of the liver is sudden in onset and frequently occurs without premonitory symptoms. Immediate transfusions of blood, and later, ligation of the left coronary vein and possibly splenectomy, have produced satisfactory results in several instances, particularly those in which cirrhosis of the liver has been a part of Banti's disease.

Although hemophilia and pseudohemophilia occur infrequently, the latter may be unsuspected until bleeding from operated regions calls attention to the blood dyscrasia.

Cell free, normal plasma contains a substance which will shorten the coagulation time of the blood of patients who have hemophilia and this knowledge has been used successfully to stop the bleeding of such patients. Globulin can be precipitated from normal plasma which is equally as effective in controlling hemorrhage as cell free, normal plasma (29).

Purpura hæmorrhagica, or essential thrombocytopenia, is characterized by hemorrhagic phenomena and by a marked reduction in the number of platelets in the blood, the surgical treatment of which consists in the removal of the spleen. This procedure should be done in the interval between hemorrhagic episodes.

Although aplastic anemia and acute leucemia are diseases in which the hemorrhagic tendency plays a rôle, their occurrence is infrequent among surgical patients. Treatment consists of the palliative administration of blood.

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CURRENT METHODS IN THE MANAGEMENT OF PEPTIC ULCER

VERNE C. HUNT, M.D., F.A.C.S., Los Angeles, California

THE surgical treatment of peptic ulcer has by this time advanced well into what may be regarded as its third era. The first era was that of development and embraced approximately 25 years, from 1885 to 1910. During this developmental period the operations of gastro-enterostomy, gastroduodenostomy, gastric resection with its various methods of restoring gastro-intestinal continuity, and the several operations upon the pylorus and the first portion of the duodenum, designated as pyloroplasty, were developed and used in certain cases of peptic ulcer. The second era of gastroduodenal surgery was that of experience and included the years approximately from 1910 to 1930. During this period of experience much was learned of the normal gastroduodenal physiology, of the changes in gastroduodenal physiology in the presence of duodenal or gastric ulcer, and of the effects upon normal or disturbed physiology produced by the various operations devised and employed in the treatment of peptic ulcer. The vast experience of surgeons throughout the world in the surgical treatment of peptic ulcer has resulted in considerable unanimity of opinion, particularly so regarding the indications for surgical treatment in cases of peptic ulcer, and the purposes of surgical operations under the various circumstances. That unanimity of opinion does not exist among surgeons as to just the type of surgical procedure to be employed under certain circumstances emphasizes the well known fact that no single operation may be used routinely in every case, and that no operation, even though it seems to be the one best suited to the particular circumstances, is followed by the anticipated and highly desirable satisfactory result in every case. It would seem that the surgical profession has emerged from that second or stabilizing period of gastroduodenal surgery and has advanced well into another era where by reason of its past experience it is well fortified with knowledge of the "how," the "why," the "whether," and the "when" of the various surgical procedures currently employed in the treatment of peptic ulcer.

Presented before the Clinical Congress of the American College of Surgeons, Philadelphia, October 16–20, 1939.

The statement has been made by many that peptic ulcer is not a local disease, but is a local manifestation in the stomach or duodenum, or both, of a constitutional disturbance. Be that as it may, it is generally accepted that even though a definite constitutional disturbance is recognizable and may be definitely designated as such in many instances the treatment for the most part must be directed to the ulcer. Furthermore, whatever etiological relationship gastric acidity has to peptic ulcer it is well known that in general, whether the treatment is entirely by medical methods or by surgical intervention, the prospects of a permanent cure depend to a large extent upon the thoroughness with which the treatment or the operation controls gastric acidity and gastric secretion, either through dilution and neutralization or through quantitative reduction.

SURGICAL INDICATIONS IN PEPTIC ULCER

The results of careful, competent, medical management are eminently satisfactory in many cases of uncomplicated duodenal and gastric ulcer. This is particularly true in those instances in which the symptoms are of short duration, but it tends to become less true after chronicity has been established. The attitude of the clinician regarding the effectiveness of continued medical treatment, the degree of disability which the lesion provokes, and the surgical facilities and skill available, are all factors which determine the number of medical cures which the patient must experience after chronicity of the lesion has been established, or the number of symptomatic

uncomplicated recurrences he should endure under medical treatment before surgical consideration of the lesion may be entertained What the results of medical treatment actually are has been most difficult to ascertain. Brown, in 1930, reported the results of medical treatment in 1,130 cases of peptic ulcer from his own services, those of the late Dr. Sippy, and associates at the Presbyterian Hospital in Chicago. He stated that 66 per cent of the patients were cured or greatly improved, 10 per cent obtained a fair medical result, and 13+ per cent had been operated upon subsequently elsewhere. While this study was based upon 1,130 patients treated medically and 94 treated surgically, it was stated that 1,900 patients had been treated, but the subsequent course of events was not known in more than one third of the cases. St. John and Flood reported the results of medical treatment in 225 cases of duodenal ulcer in a recent review. All of the patients had been admitted to the hospital at one time or another and it was found that the incidence of recurrence in patients, who were accurately followed, varied from 65 per cent within the first 2 years of the follow-up period to 75 per cent in the patients who had been followed for more than 5 years. There was a mortality rate of 2.7 per cent in this selected group of patients during medical management. Among their conclusions these authors stated, "the majority of patients with persistent pain lasting for more than 2 weeks during hospital treatment had an unsatisfactory course; also that surgical therapy should be considered for patients having multiple hemorrhages and persistent pyloric obstruction."

It is the consensus of opinion that surgical treatment of an uncomplicated peptic ulcer is indicated only after intractability to or impracticability of medical management has been proved and established; also that the complications of perforation, gastric retention, and repeated massive hemorrhage constitute the important indications for surgical procedures.

Acute perforation of a duodenal or gastric ulcer constitutes a serious abdominal emergency usually characterized by such clinical manifestations that the urgency of surgical intervention is immediately apparent. In the case of acute perforation of a peptic ulcer, operation is performed as a life-saving measure and embraces only one objective—closure of the perforation. Although simple closure of the perforation does not provide the patient with assurance against recurrence, the surgeon's responsibility in the emergency is not that of a permanent cure of the ulcer. Experience has by this time proved very conclusively that usually a more extensive surgical procedure than closure of the perforation mitigates against recovery. Departure from the policy of simple closure of a perforation is seldom justified even though symptoms of ulcer recur in a large percentage of patients and secondary operation curative in purpose is often required. In spite of the fact that the time interval between perforation and surgical closure bears a distinct relation to the mortality rate of perforation, Roscoe Graham has deliberately prolonged this time interval in certain instances by as much as 8 hours for purposes of instituting pre-operative treatment of shock and secondary manifestations of the perforation with profit to the patient. He has recently reported 51 consecutive operations for perforated duodenal ulcer with but a single fatality.

Protective perforation of a duodenal or gastric ulcer occurs much more frequently than the acute perforation of an ulcer into the free peritoneal cavity. In many instances such perforation is characterized by clinical manifestations of a subacute inflammatory process; in others the perforation occurs insidiously by penetrating a structure to which, because of previous inflammatory episodes, the ulcer base has become attached. Resistance to medical treatment characterizes many of these lesions, and the type of pain in those cases of ulcer which penetrate the pancreas often leads to a clinical diagnosis of penetrating ulcer. That such protective perforation and penetration occur frequently has recently been brought to my attention following the review of the surgical findings and operations instituted in patients with duodenal and gastric ulcers upon whom I have operated during the past 15 years. Subacute or chronic perforation and penetration of nearby structures,

most frequently the pancreas, occurred in 120 cases or 13.8 per cent of 865 cases of duodenal ulcer, and in 32 per cent of 137 cases of gastric ulcer. The incidence of subacute or chronic perforation and penetration in the cases operated upon during the past 5 years has been 31 per cent in duodenal ulcer and 50 per cent in gastric ulcer. The higher incidence of this complication during recent years may be explained it seems on the basis of a narrowing down of the indications for surgical treatment of peptic ulcer quite definitely to complications.

Gastric retention when due to the edema of reactivation of ulcer usually is temporary and subsides following medical treatment, but tends to recur. Persistence of gastric retention due to true cicatricial pyloric stenosis of a duodenal ulcer or to a disturbance of gastric motility in the presence of a gastric ulcer is amenable only to surgical treatment.

The bleeding peptic ulcer presents a serious problem to both the internist and the surgeon and usually the question arises as to whether medical management shall be relied upon or whether an operation shall be performed. It is a commonly held and frequently expressed opinion that hemorrhage is rarely a fatal complication in peptic ulcer and is best treated by non-surgical methods. It is well known that bleeding occurs in from 20 to 35 per cent of the cases of peptic ulcer. In many of the cases the bleeding is manifested through persistence of a secondary anemia and the presence of occult blood in the stool. As a rule these cases provide no serious problem because no emergency arises. Should healing of the ulcer not occur with resultant disappearance of blood from the stool and improvement in the blood picture following careful medical management, an operation of election may be necessary. It is the massive exsanguinating type of hemorrhage which constitutes a serious emergency.

Without bringing together all available data pertaining to the seriousness of the complication of hemorrhage from a peptic ulcer, the observations of Allen and Benedict, in Boston, and those of Goldman, in San Francisco, are particularly noteworthy. Death from exsanguination occurs in from 10 to 15 per cent of patients who suffer massive hemorrhage from a peptic ulcer. These authors, among others, have emphasized the observation that the danger of a fatality rises rapidly with advancing age and is materially higher in patients beyond the age of 50 years than it is in younger individuals. Recovery from a massive hemorrhage offers no assurance that subsequent bleeding from a duodenal or gastric ulcer will not occur. Means has directed attention to the observation that as the mortality from massive hemorrhage increases with age, so, too, does it increase with each recurrence. There are now many internists and surgeons alike who subscribe to the following policy in the treatment of massive hemorrhage from a duodenal or gastric ulcer: (1) In the treatment of massive hemorrhage from peptic ulcer, whether primary or recurrent, one of the most important measures is transfusion for the purpose of restoring blood volume. (2) In the patient under 50 years of age operation seldom if ever is indicated during the hemorrhage. (3) Repetition of massive hemorrhage 2 or more times in patients under 50 years of age, warrants surgical intervention as soon as the patient's general condition will permit an operation of election with a maximum degree of safety. (4) In patients more than 50 years of age, operation is advised in those patients who show no improvement as the result of intermittent, repeated or continuous transfusion in from 12 to 24 hours. (5) In patients more than 50 years of age who have recovered from a massive hemorrhage through the employment of non-surgical measures, fate should not again be tempted, but surgical measures advised.

Acute massive hemorrhage from a peptic ulcer which is not subsiding is a most dramatic situation, and when matters proceed from bad to worse and bleeding continues under non-surgical treatment including the transfusion of blood, early surgical attack directly upon the bleeding lesion even though the hazards are great, may provide the only life-saving method. Surgical treatment during active hemorrhage from an ulcer embraces 2 important principles: that the operation be performed early, and that the operation be a direct one with excision of the bleeding lesion.

Finsterer, Gordon-Taylor, and others have emphasized the importance of an early operation, one performed within 24 or 48 hours.

The problem of massive gastro-intestinal hemorrhage is frequently complicated by a lack of knowledge as to what the source of the bleeding may be. Those cases in which the diagnosis of peptic ulcer has not been established previously often provide considerable diagnostic difficulty through the inadvisability of employing the usual methods of diagnosis during or immediately following the hemorrhage. Likewise, repeated massive gastro-intestinal hemorrhage may and does occur from other lesions of the tract. The futility of prolonged ulcer regimen and medical management for repeated massive hemorrhage has been observed on a number of occasions, when surgical exploration has disclosed that an ulcer in a Meckel's diverticulum or a benign tumor of the small intestine instead of an ulcer of the stomach or duodenum has been responsible for the bleeding.

In general the mortality rate following surgical intervention for massive hemorrhage from peptic ulcer has been greatly in excess of the mortality when treatment has been entirely by non-surgical measures, because it has been the mortality of surgical procedures instituted late in the cases of medical failure, and not the mortality rate of early surgical treatment in all cases of bleeding ulcer. Finsterer has recently reported only 3 deaths following gastric resection in 71 cases of bleeding ulcer, a mortality rate of 4.2 per cent. Massive hemorrhage may be accepted as a distinct indication for surgical treatment, whether the operation is done at a time of election or as an emergency procedure during the hemorrhage, only on the basis that surgical skill and adeptness in the performance of the operation of gastric resection are available.

These general considerations apply to both duodenal and gastric ulcer as indications for surgical treatment. There is one more factor which must always be considered in gastric ulcer, that is, the ulcer-carcinoma relationship. Reference is not made herein particularly to the question of malignant degeneration of a benign gastric ulcer, but instead attention is directed to the difficulties often encountered in differentiating by clinical and roentgenological evidence between a strictly benign gastric ulcer and an early carcinoma or a carcinomatous ulcer. Experience has proved that doubt may justly be cast upon many lesions exhibiting the clinical and roentgenological evidence of a gastric ulcer. When such doubt exists, the discerning clinician and the experienced roentgenologist, through acquired wisdom, justly seek refuge in the diagnosis of a "lesion of the stomach" (Figs. 1, 2, 3, and 4.) The therapeutic test in which clinical and roentgenological, and, if necessary, gastroscopic observation is conducted for a period of 3 or 4 weeks, during which time intensive medical treatment of the gastric lesion is carried out, has found a distinct place in the differential diagnosis of some of these gastric lesions. The value of the test is entirely dependent upon the competency of the interpretation which may be placed upon the observations, and faulty interpretation has in the past occurred too frequently. It should be borne in mind that temporary clinical improvement has often been noted following dietary and other forms of medical management of ulcer when instituted in a patient who harbors a gastric carcinoma. Also, roentgenological and gastroscopic observations at repeated intervals are subject to error in interpretation even by competent observers in these respective fields. There is today unanimous opinion that when any doubt exists regarding the true nature of the lesion, surgical treatment is indicated.

TYPES OF OPERATION

Surgical procedures for duodenal and gastric ulcer, curative in purpose, are of 3 general types: (1) The indirect operations of gastro-enterostomy and gastroduodenostomy with or without excision of the ulcer; (2) plastic operations on the pylorus with or without excision of the ulcer; and (3) gastric resection with one method or another of restoring gastro-intestinal continuity.

Gastro-enterostomy has served in the past and so continues to serve the purposes of surgical treatment to best advantage in those cases of gastric retention due either to cicatricial pyloric stenosis secondary to chronic

duodenal ulcer, or to loss of gastric motility in certain cases of gastric ulcer and in other instances following local excision of a gastric ulcer. The results of gastro-enterostomy in the cases of true cicatricial pyloric stenosis of duodenal ulcer are the most brilliant in gastro-duodenal surgery, from the standpoint not only of ultimate results, but also as pertains to mortality. However, experience by many has by this time proved quite conclusively that gastro-enterostomy may not be employed with similar success in other cases of duodenal ulcer and its complications. Mitigating against the results of gastro-enterostomy has been the frequency with which new ulcer occurs in or about the stoma. Gastrojejunal or jejunal ulcer has been reported to occur in from 1.7 to 24 per cent following gastro-enterostomy. However, the general average does not exceed 5 per cent. Judd and Hoerner, in reviewing a large series of gastrojejunal and jejunal ulcers, found that the symptoms appeared in 34 per cent of the cases within 6 months after gastro-enterostomy, and within 1 year in approximately 50 per cent of the cases. It is of interest that in many instances satisfactory results follow gastro-enterostomy for many years with subsequent development of a gastrojejunal or jejunal ulcer. Within the past 6 months C. G. Toland and I have each operated upon a patient at St. Vincent's Hospital for obstructing and bleeding gastrojejunal ulcer in each of which the gastro-enterostomy had been performed by the same surgeon in 1911 or 29 years ago. In one of these patients there was complete relief of symptoms following gastro-enterostomy for 17 years, and for 15 years in the other. Selinger has recently reported a case of acute perforation of a marginal ulcer occurring 30 years after posterior gastro-enterostomy. Variable as the incidence of gastrojejunal and jejunal ulcer may be, the new ulcer has proved to be of greater seriousness from the standpoint of complications and resistance to medical management as well as in the fact that the magnitude of the surgical procedures necessary is greater than that of the gastro-enterostomy employed for the relief of the original ulcer. Even though gastrojejunal and jejunal ulcers mitigate against entirely satisfactory results following gastro-enterostomy, it should be borne in mind that no surgical procedure for duodenal ulcer provides complete assurance against a new or anastomotic ulcer and that gastro-enterostomy can be performed with little risk under certain circumstances in which the risk of any other operation might be great and not justified. Also, as an adjunct to conservative local excision of a gastric ulcer, gastro-enterostomy continues to be most useful.

Gastroduodenostomy has supplanted the simple Heinecke-Mikulicz type of pyloroplasty with its various modifications, and constitutes an operation whereby the purposes of operation for duodenal ulcer may often be served. The method of Finney and that of Judd facilitate excision of the ulcer when advisable, but neither procedure is applicable in all cases of duodenal ulcer. The lateral anastomosis of Jaboulay, so modified as to utilize the second and third portions of the duodenum, has a field of usefulness in certain cases of duodenal ulcer as a primary operation, fulfils many physiological requirements, and has been followed by few reported instances of anastomotic ulcer (Figs. 5, 6 and 7). Lateral gastroduodenostomy has likewise served a useful purpose as a conservative operation, instead of partial gastrectomy following the taking down of a gastro-enterostomy and excision of a gastrojejunal or jejunal ulcer. I have successfully employed lateral gastroduodenostomy instead of partial gastrectomy after taking down the gastro-enterostomy, closing the stomach, jejunum, and colon in 2 cases of gastrojejunocolic fistula. Immediately after reporting entirely satisfactory results 6 months ago, in 22 cases of lateral gastroduodenostomy as a primary operation for duodenal ulcer and as an adjunct to taking down gastro-enterostomy and excising marginal or jejunal ulcers, I had occasion to perform the operation for gastrojejunal ulcer, which was followed immediately by symptoms of recurrent ulcer becoming progressively worse and finally exhibiting clinical manifestations of subacute perforation. Operation less than 3 months following the gastro-duodenostomy disclosed a huge anastomotic ulcer which had perforated into the hepatic

flexure of the colon and resulted in a gastro-duodenocolic fistula. The operation of partial gastrectomy and closure of the colonic fistula was not followed by recovery. Even though anastomotic ulcer following lateral gastro-duodenostomy has also been reported by Wilkie, Roscoe Graham, and others, this operation still has a definite field of usefulness though limited.

Partial gastrectomy is applicable in many cases of gastric ulcer, particularly in those instances in which the ulcer is situated in the pyloric half, but in selecting a surgical procedure for gastric ulcer one should remain mindful of the safety of the operation and the excellent results which have followed local excision and posterior gastro-enterostomy in certain ulcers at or about the lesser curvature of the stomach. In my own experience in 137 patients with gastric ulcer upon whom I have operated, local excision and gastro-enterostomy was the operation employed in 40 per cent and partial gastrectomy in 43 patients or 31 per cent. In performing partial gastrectomy for gastric ulcer, the safety of the operation is materially enhanced irrespective of the amount of stomach which is removed, if the duodenum is avoided and the resection is limited distally by the pyloric ring. Because of the frequency with which a posterior anastomotic ulcer has followed the segmental so called sleeve resection with end-to-end anastomosis of the 2 segments, this type of resection has become practically obsolete. In performing partial gastrectomy for peptic ulcer the magnitude of the resection among other factors determines which one of the various types of gastro-intestinal restoration is most readily applicable, and of these the Pólya, Balfour Pólya, Billroth I and II, and the various modifications of Finsterer, Hofmeister, and Haberer are those most frequently employed. The technical details of these procedures have been illustrated and described by Cutler and Zollinger and others.

Partial gastrectomy in the treatment of duodenal ulcer has advanced to an important position. Not all surgeons have subscribed to the operation with the enthusiasm of Berg, Lewisohn, and others, but many are employing partial gastrectomy much more often than formerly in cases of duodenal ulcer. The frequency with which gastro-enterostomy and other conservative operations have failed to provide assurance against subsequent bleeding in the hemorrhagic duodenal ulcer, has led to the generally accepted policy of instituting direct surgical attack upon the bleeding lesion and including excision of the ulcer as part of the surgical procedure. As Balfour has said, this is often most readily accomplished by partial duodenectomy and gastric resection. Likewise, in the ulcer which has perforated as a protective perforation, particularly in those instances in which the pancreas has been penetrated and a crater ulcer exists, experience has proved that partial gastrectomy facilitates either excision or exclusion of the lesion with eminently good results. It has been during the last few years only that I have subscribed to the idea of partial gastrectomy in duodenal ulcer and have employed the operation with increasing frequency, approximately 30 per cent of the cases, particularly in the hemorrhagic and in the penetrating ulcers.

Roscoe Graham stated before the Clinical Congress of the American College of Surgeons 2 years ago that partial gastrectomy had been performed in 131 or 53 per cent of 246 cases of duodenal ulcer operated upon with a mortality rate of 2.25 per cent. This is an enviable record but is misleading, for in general the mortality rate of partial gastrectomy for duodenal ulcer as reported by others highly qualified in gastroduodenal surgery varies from 5 to 10 per cent. Many factors enter into the risk of partial gastrectomy for duodenal ulcer, most important of which is whether partial duodenectomy with excision of the ulcer is included in the operation or whether the gastric resection is limited distally by the pylorus. The technical difficulties at times are great in performing partial duodenectomy and gastric resection in the case in which an ulcer of the posterior duodenal wall penetrates deeply into the head of the pancreas or when considerable inflammatory reaction results from subacute protective perforation of an ulcer. Even though resection provides greater certainty of cure and permanent relief of symptoms under such cir-

Fig. 1. Large filling defect of a perforating lesion of the posterior gastric wall.

cumstances than a more conservative operation, the price in terms of risk and mortality for this added certainty of cure is often too high.

Fig. 3. Filling defect showed questionable decrease in size during few weeks intensive treatment.

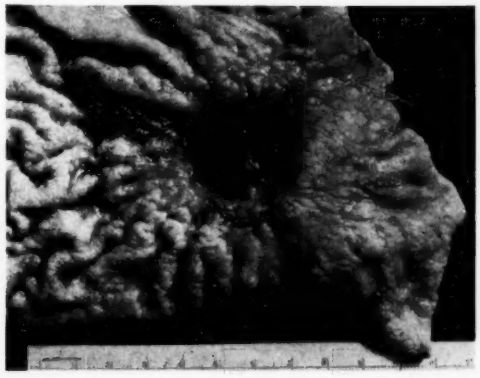

Fig. 2. Resected stomach (same case as Fig. 1), huge benign ulcer penetrating body of pancreas.

The failures following the various operations for duodenal ulcer are due for the most part to reactivation of the original ulcer or development of an anastomotic ulcer. Heuer's extensive review disclosed that the incidence of anastomotic ulcer following gastro-enterostomy varied from 0.9 to 6.9 per cent with an average of 3 per cent; also that jejunal or anastomotic ulcer followed partial gastrectomy in 0.6 to 6 per cent of the cases with an average incidence of 1.9 per cent. Finsterer reviewed his experience in 331 operations for recurrent or anastomotic ulcers before the Clinical Congress one year ago. He said that the mortality rate of secondary radical operation for gastrojejunal ulcer following gastroenterostomy was 8.1 per cent as compared

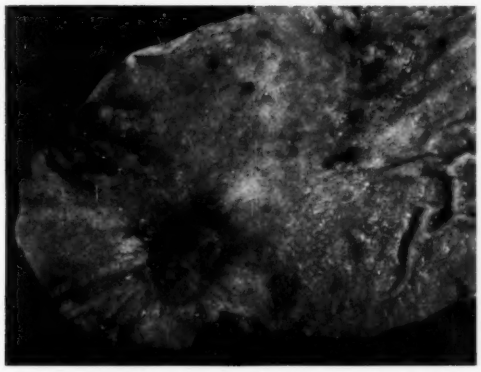

Fig. 4. Resected stomach (same case as Fig. 3), lesion proved to be a carcinomatous ulcer.

Fig. 5. In performing lateral gastroduodenostomy the filmy reflection of the peritoneum is divided lateral to the duodenum, which allows elevation of the duodenum from its retroperitoneal position.

with 23.5 per cent for the radical operation for anastomotic ulcer following partial gastrectomy. It seems to me that at the present time the status of partial gastrectomy in the treatment of duodenal ulcer may be expressed about as follows: Excision of the hemorrhagic or recurrently bleeding duodenal ulcer and the penetrating duodenal ulcer is highly desirable and in many instances may be most satisfactorily accomplished by partial duodenectomy and gastric resection. In general and by and large the risk and mortality rate of partial gastrectomy are 3 to 5 times as great as in one or another of the direct or indirect conservative operations. The chance of an anastomotic or jejunal ulcer developing following partial gastrectomy is approximately one-half as great as that following gastro-enterostomy, but the mortality rate of radical surgical treatment of gastrojejunal ulcer following partial gastrectomy is approximately 3 times as great as it is for gastrojejunal ulcer following gastro-enterostomy. While radical partial gastrectomy has become an operation of increasing usefulness under certain circumstances and conditions in duodenal ulcer, the purposes of surgical intervention in many cases of duodenal ulcer are still served with distinction and greater safety when one or another of the conservative operations is employed.

To achieve the most in the surgical treatment of duodenal and gastric ulcer, it is essential that the indications for operation be rigidly adhered to, and that no operation be

Fig. 6. Mobilization of the duodenum facilitates its approximation to the antrum of the stomach without angulation or undue tension.

Fig. 7. The anastomosis is constructed without the use of clamps on either the stomach or the duodenum.

used as a routine procedure. Instead, that surgical procedure should be selected which most nearly meets the purpose of surgical intervention and which after a thorough survey of the situation upon opening the abdomen may be carried out with the maximum degree of safety.

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FOREIGN BODIES IN THE AIR AND FOOD PASSAGES

Observations on End-Results in a Series of Nine Hundred Fifty Cases

LOUIS H. CLERF, M.D., LL.D., F.A.C.S., Philadelphia, Pennsylvania

THE problems of diagnosis and treatment of foreign bodies in the air and food passages as viewed today should be considered recent additions to the field of medicine. Although no records are available, one may safely assume that foreign body accidents have occurred since the beginning of the human race. There are scattered references in early medical literature. In 1759, Louis read his *Memoir on Bronchotomy* before the Royal Academy of Surgery at Paris. He collected all of the cases of foreign body then known, 28 in number, and presented all that had been learned concerning the subject up to that time. His work was outstanding and created favorable comment.

The first systematic study of this subject was made by Samuel D. Gross who published his *Practical Treatise on Foreign Bodies in the Air Passages* in 1854. This contribution still stands as a monument to the remarkable insight and keen powers of observation possessed by the medical men of his day. With the art of physical diagnosis in its infancy, the incandescent lamp unknown, the roentgen ray undiscovered, and no Chevalier Jackson to devise new tubes and forceps to solve mechanical problems, one can but express amazement that so many patients not only survived the procedures employed but also were restored to health. Gross was an outspoken advocate of bronchotomy or tracheotomy in the treatment of foreign bodies in the air passages, and he believed it should be resorted to the "minute it is known that there is a foreign substance in the lung."

Weist's results led him to carry out a study of the methods of treatment for foreign bodies in the air passages particularly to determine if bronchotomy should be employed. On June 1, 1882, at a meeting of the American Surgical Association held in Philadelphia, he reported on a series of 1,000 cases of foreign bodies in the air passages. Briefly, in 63 cases the foreign body was removed by measures other than bronchotomy. Of the remaining 957 cases, 599 were not subjected to bronchotomy with 139 fatalities, a mortality rate of 23.2 per cent. Bronchotomy was performed in 338 cases with 93 deaths, or 27.4 per cent, a difference of over 4 per cent in favor of non-interference. Apart from his observations it is of interest to learn that 57 years ago the mortality rate in cases of recognized foreign bodies in the air passages was more than 24 per cent, and that attempts at removal by bronchotomy increased the mortality rate by over 4 per cent.

Foreign bodies in the esophagus were removed by employing a blunt metallic hook, esophageal forceps, a noose fashioned of wire, a sponge or piece of linen attached to the end of whalebone, or a gum elastic catheter. Coins were removed with a coin catcher. The horse hair probang, a miniature form of umbrella, was commonly employed. If the object could not be extracted, it was pushed into the stomach. Induced vomiting and the swallowing of bulky foods often were resorted to. In certain instances external incision was employed. There are no statistical references to failures or successes. It is presumed that these blind methods of removal frequently resulted in injury to the esophagus with fatal mediastinal infection.

In compiling data concerning end-results in foreign body cases one is beset with many difficulties. Complications developing while a patient is under observation in the hospital may be recorded; immediate end-results, namely recovery or death, can be reported. Accurate data on sequelæ are secured, however, in a relatively small group. The reasons for this are the wide geographical distribution

From the Department of Laryngology and Bronchology, Jefferson Medical College.

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of patients, difficulty to evaluate data submitted, and failure to reach patients by accepted follow-up methods. In this series over 88 per cent were ward cases. The economic status of these patients was not conducive toward maintaining a settled place of abode.

A series of 950 consecutive cases of foreign bodies in the air and food passages removed by endoscopic means is reviewed from the standpoint of postoperative complications, sequelæ, and fatalities. No attempt shall be made to consider each class of foreign bodies separately or in detail. Certain factors influence results. Among these are the age of the patient, the character of the foreign body, its length of sojourn, its effects in the production of pathological changes, and previous attempts at removal. The location of the foreign bodies was recorded anatomically as follows: 413 in the air passages consisting of 19 in the larynx, 37 in the trachea, and 337 in the bronchi. In the food passages there were 537, divided as follows: hypopharynx 48, esophagus 457, and stomach 32.

Vegetal foreign bodies. The peanut still enjoys great popularity as a bronchial foreign body. Among 215 objects consisting of nuts, seeds, and shells there were 115 peanuts, 16 grains of corn (maize), 15 beans, 12 watermelon seeds, and 6 timothy heads as well as a great variety of other nuts, seeds, and shells. Of the 115 cases of peanut all but 4 occurred in patients under 10 years of age. Seventy-eight occurred in children, 3 years of age or less, the youngest being 9 months. The length of sojourn of the foreign body varied from a few hours to 6 months. In 19 cases the peanut was present from 1 to 6 months. Of the 100 cases of nuts, seeds, and shells other than peanuts, 15 occurred in patients under 1 year of age, the youngest being 8 months.

The cases of bean in the bronchus numbering 15 are noteworthy. Atelectasis was a common anatomical finding and was associated with severe laryngotracheobronchitis. All of the patients but one were from 13 months to 5 years of age. The incidence of tracheotomy and the mortality rate were higher in these than in any other group.

The cases of timothy head in the bronchus are of interest. Four patients were under 3 years of age. In 3 the length of sojourn was 21, 9, and 4 months, respectively. In these extensive suppurative changes had occurred. In 1 child, 8 months old, tracheotomy became necessary following bronchoscopic removal of the foreign body which had been aspirated 9 days previously. In 1 patient pyopneumothorax developed. Curiously, there were no fatalities.

Bones ranked next to vegetal foreign bodies in order of frequency. Of 166 cases, 19 were removed from the air passages and 147 from the food passages. It is of interest to note that bones in the bronchus commonly are overlooked and consequently are complicated with extensive suppurative changes. In 16 the sojourn of the foreign body varied from 1 month to 7 years. There were 2 deaths in this group occurring in children, 19 months and 2 years old, respectively.

Lodgment of bones in the food passages results from carelessness in the preparation of food and in eating. This accident is common in persons wearing dentures. Unlike bones in the airway, sojourn of bones in the food passages usually is relatively short due to the distress produced by constant swallowing efforts and injury to the esophageal wall. When one considers the character of the fragments swallowed, namely, irregular, jagged-edged, and sharp pointed objects, the thin esophageal wall, and the constant presence of infected mouth secretions, it is amazing that fatal complications are not more often encountered. In 2 patients complications developed which proved fatal.

Coins, *discs*, and *buttons* are common esophageal foreign bodies in children. Fortunately, the rounded edges produce little trauma so that complications resulting directly from the foreign body itself are uncommon. In this series there were 89 cases of coins and discs in the food passages and 2 in the air passages. Cases of buttons in the esophagus numbered 21. A majority occurred in small children and in over one-half the button was overlooked for periods varying from 1 to 9 months. In these there was marked peri-esophageal swelling with tracheal compression so that respiratory symptoms dominated the clinical picture (Fig. 1).

Dental objects. Dentures usually are found as esophageal foreign bodies in adults while teeth commonly occur as bronchial foreign bodies and are more often observed in the young. Of 48 foreign bodies of dental origin, 26 teeth, 3 fillings, and 3 dentures were removed from the air passages, and 16 dentures were removed from the esophagus. Teeth usually are contaminated with the bacterial flora of the mouth, are often overlooked, and usually produce marked bronchial obstruction. As a result, severe pulmonary infection is common. One fatality occurred in a child 22 months old following bronchoscopic removal.

Safety pins constitute the most difficult and potentially the most dangerous of all foreign bodies. With an occasional exception the pins are open with the point and keeper directed upward. A total of 97 safety pins was removed as follows: from the air passages, 21; from the upper food passages, 65; and from the stomach, 11. A majority of the patients were infants and little children. In 9 instances of pins being removed from the air passages, the patients were under 5 years, the youngest being 3 months. Sixty-nine of the 76 safety pins removed from the food passages occurred in children under 7 years of age of which 47 were under 1 year. Two of these were 3 months and 5 were 4 months old. There was 1 fatal case.

In addition to these classes of foreign bodies there were aspirated many specimens of hardware, particularly tacks and screws, also beads, ammunition, toys, jewelry, and other objects which usually produced partial or complete bronchial obstruction. There also were many irregular objects as jackstones, hardware, toys, jewelry, and other unclassified materials which lodged in the food passages producing obstruction and variable degrees of injury to the esophageal walls.

COMPLICATIONS AND SEQUELÆ OF FOREIGN BODIES IN THE AIR PASSAGES

Dyspnea. Although occasionally observed in large, irregular, esophageal foreign bodies producing tracheal compression, dyspnea more often occurred in foreign bodies in the air passages. It was observed most frequently in cases of vegetal foreign bodies. Many of these substances set up a septic laryngotracheobronchitis in young children who constitute a majority of the vegetal foreign body cases. On the other hand, metallic foreign bodies in the air passages rarely caused dyspnea unless there had been previous instrumentation.

Tracheotomy was performed for the relief of obstructive dyspnea and to aid in ridding the tracheobronchial tree of excessive secretions in 52 cases of foreign bodies in the air passages. This included 11 patients in whom tracheotomy had been performed prior to admission of the patient to the clinic. In 3 of these it was performed as an emergency measure before attempted removal of the foreign body; in 5 bronchoscopy had been performed and tracheotomy became necessary before admission, while in the remaining 3 patients bronchoscopy had been done elsewhere and tracheotomy was performed as soon as the patients were admitted to the clinic. In 41 tracheotomy was necessary for relief of dyspnea which developed following endoscopic procedures performed at the clinic. Unsuccessful attempts at bronchoscopic removal had been made elsewhere in 10 patients before admission. Forty-three of the 52 tracheotomies were performed in cases of vegetal foreign body. Of these, 16 were cases of lodgment of peanuts, 27 were cases of nuts, seeds, and shells other than peanut, and the remaining cases included a tooth, a bone, and metallic objects. It is of interest to note that tracheotomy was necessary in 10 of the 15 cases of bean in the bronchus while it was necessary in but 1 of 12 cases of watermelon seed.

Complications of tracheotomy. Subcutaneous emphysema of varying degree occurred in a number of the patients, which was limited to the neck usually and cleared up promptly. Mediastinal emphysema following tracheotomy developed in 2 cases; one, aged 19 months, with a fragment of bone in a bronchus, the other, aged 22 months, with a tooth in the bronchus. There was a brief interval between the bronchoscopy and the development of obstructive laryngeal dyspnea, and the emphysema did not develop until after tracheotomy. Therefore, it was the opinion

Fig. 1. Roentgenogram of a child, aged 1 year, made on admission to bronchoscopic clinic 23 days after swallowing a button. There was cough, slight dyspnea with wheezing, and dysphagia for solid foods. A flat roentgenogram made on the day of the accident was negative for foreign body. A probang was passed with negative results. Roentgenogram after swallowing barium mixture revealed foreign body in esophagus, marked peri-esophageal swelling and forward displacement and compression of trachea. (Film by Dr. W. F. Manges.)

a b

Fig. 2. Roentgenogram made of a child, aged 4 years, 31 days after choking on a .22 calibre bullet. With the occurrence of fever 5 days after the accident a diagnosis of pneumonia was made. This did not run the usual course and a diagnosis of empyema was considered. Roentgenographic study of the chest revealed the foreign object. The bullet completely occluded the right bronchus distal to the orifice of the upper lobe bronchus, a. The cloudiness distal to the obstruction is due to atelectasis and drowned lung. Following bronchoscopic removal of the bullet, the lower lung cleared slowly, b. Prior to uncorking of bronchus temperature range was septic in type; this returned to normal after removal of bullet, c. A communication 11 years after removal indicated that the patient was free from respiratory symptoms and the lungs were normal.

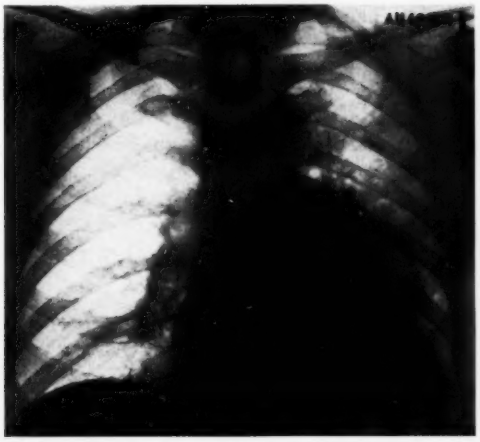


Fig. 3. Roentgenogram of man, aged 49 years, revealed an abscess cavity with fluid level in the lower lobe, left lung. There was cough and expectoration of fetid pus of several months' duration. Following bronchoscopic removal of fish bone patient recalled choking on a fish bone 10 months previously. (Film by Dr. J. T. Farrell.)

that air entered the mediastinum from the tracheal opening. Both cases terminated fatally. In no patient did cellulitis of the neck

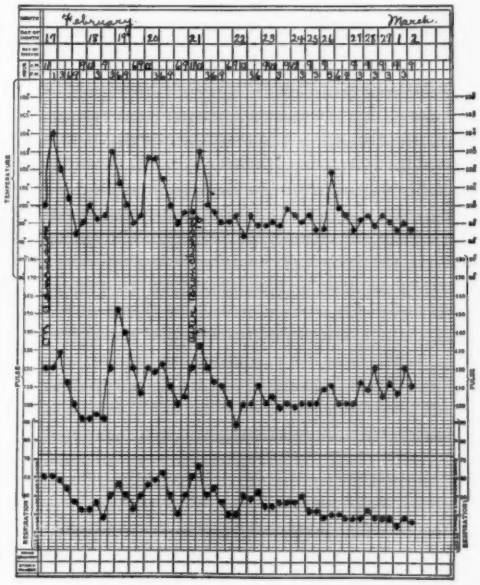


Fig. 2c.

develop. The tracheotomy wounds were allowed to remain unsutured and this undoubtedly accounted for the absence of serious infection. No unusual difficulties were encountered with decannulation.

Emphysema. Extensive subcutaneous and mediastinal emphysema complicating bronchial foreign body and occurring prior to any endoscopic manipulation has been observed in 3 patients. In 2 the foreign body, a peanut, produced obstructive emphysema of the involved lung. There was no pneumothorax. In the third case a bean in the bronchus produced obstructive atelectasis of the entire right lung. There was marked emphysema of the neck and mediastinal tissues with a slight, right-sided pneumothorax. All of these patients recovered following bronchoscopic removal of the foreign body although tracheotomy was performed in the case of bean in the bronchus for relief of obstructive laryngeal dyspnea following bronchoscopy.

Pulmonary abscess. Abscess of the lung is an infrequent complication of foreign body in the air passages. Suppuration is common particularly in cases of long sojourn with marked bronchial obstruction. Retention of secretion distal to a foreign body with the development of drowned lung may present the clinical picture of pyothorax, atypical pneumonia, or pulmonary abscess (Fig. 2). Abscess based on the roentgenographic demonstration of a cavity in the lung with fluid level was observed in but one patient, a bone in the bronchus aspirated 10 months previously (Fig. 3). The abscess healed following removal of the foreign body but moderate bronchiectasis still is present.

Pyothorax. The occurrence of pleurisy with effusion was observed in 3 patients. This cleared up spontaneously in 2 and aspiration was necessary in the third. The fluid was sterile. Pyothorax may develop in cases of pleural injury produced by a foreign body or in complete bronchial obstruction with extensive suppuration. It occurs most frequently following aspiration of grass heads. Two cases were observed in this series. In 1, a case of cockleburr in the right bronchus of 4 months' duration, pyothorax developed and subsequently ruptured into a bronchus. Thoracotomy for drainage was performed and later the cockleburr was removed bronchoscopically. In the second case a timothy head had been aspirated. Pyothorax requiring thoracotomy developed within 2 weeks. The timothy head was removed by bronchoscopy 4 months later. Both of these patients recovered but undoubtedly bronchiectasis is present.

Bronchiectasis. This is the most common as well as the most serious sequela of bronchial foreign body. Bronchial obstruction with retention and ultimately infection of bronchial secretions is an important factor in the etiology of bronchiectasis. Bronchial obstruction of varying degree is a fairly constant accompaniment of bronchial foreign body. While many cases are promptly diagnosed and the foreign body removed, a relatively large group are overlooked for months, even years. Of the 413 aspirated foreign bodies, 357 were removed from a bronchus. These were studied from the standpoint of length of sojourn in the air passages. It was found that 105, almost 30 per cent, were present for periods ranging from 1 month to 30 years. Of these, 44 were lodged from 1 to 3 months, 32 from 3 to 12 months, 16 from 1 to 5 years, and 10 from 5 to 30 years. In 3 the duration could not be ascertained.

It has been difficult to learn the ultimate fate of many of these patients. The remarkable improvement following bronchoscopic removal of the foreign body has led the patient and often the physician to misinterpret this as the beginning of complete recovery. Experience has shown, however, that a large number still exhibit symptoms and signs of chronic pulmonary suppuration. Only by roentgenographic study after instillation of iodized oil may a fairly accurate knowledge of the condition of the bronchi be obtained (Fig. 4). Experience also has taught that bronchoscopic removal of the foreign body, particularly in the case of long sojourn, usually is not adequate to insure complete recovery of the involved lung (Fig. 5). Repeated bronchoscopic aspiration of secretions, removal of granulations, and dilatation of strictures may be as necessary and important for complete recovery as removal of the foreign body itself (Fig. 6).

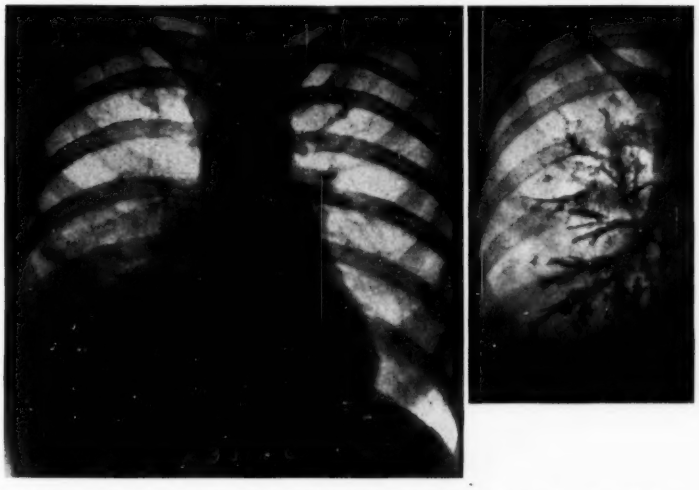


Fig. 4. Roentgenograms made in the case of a woman, aged 50 years, before removal of beef bone from the right bronchus, a, left, and after removal following instillation of iodized oil into the right lower lobe bronchus, b. The length of sojourn of the bone in the bronchus was 1 year. This patient was observed 3 years later and still has advanced bronchiectasis with cough, expectoration, and evidences of cardiac embarrassment and pulmonary emphysema. Lobectomy should be performed but the patient is a poor surgical risk.

There are additional factors other than prolonged obstruction that must be considered in the development of bronchiectasis. In several cases of partial bronchial obstruction produced by vegetal foreign bodies and in one case of tooth the sojourn did not exceed 6 days. The presence of slight bronchiectasis was demonstrated by the instillation of iodized oil following removal of the foreign body. Bacteriological studies by Dr. C. J. Bucher of secretions removed bronchoscopically have shown a predominance of streptococcus and pneumococcus. The spirochæte, so often found in pulmonary abscess, is not often observed in cases of bronchial foreign body.

In cases of well developed bronchiectasis of foreign-body origin the question of surgical treatment should be considered as a necessary part of the plan of therapy to be instituted in restoring the patient to normal (Fig. 5).

Fatalities. There were 12 deaths in the series of 413 consecutive cases of foreign bodies in the air passages. A brief synopsis of each case follows:

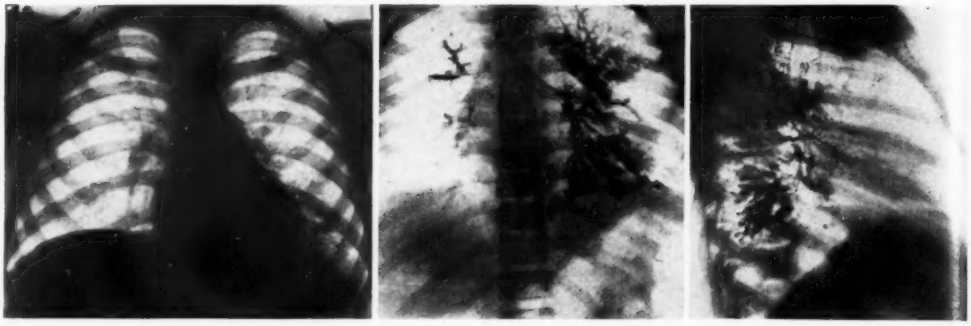
Case 1. Child, aged 3½ years; bean in right main bronchus; sojourn 2 days. One unsuccessful bronchoscopy under ether anesthesia before admission. Obstructive atelectasis of entire right lung with marked dyspnea and dehydration on admission; tracheotomy performed immediately. Bean removed; intense inflammatory changes of mucosa of trachea and bronchi present; died 10 hours later.

Case 2. Child, aged 5 years; bean in left main bronchus; sojourn 1 day with obstructive atelectasis of entire left lung. Tracheotomy performed for obstructive laryngeal dyspnea after removal of bean. Died 2 days later from septic tracheobronchitis.

Case 3. Child, aged 14 months; bean in left main bronchus; sojourn 2 days with obstructive atelectasis of entire left lung. Death resulted from blocking of right main bronchus by portion of bean lost at glottis at time of removal.

Case 4. Child, aged 1 year; peanut in right lower lobe bronchus; sojourn 5 days. One unsuccessful bronchoscopy before admission. Tracheotomy performed on second day following removal of nut. Died 11 days later from diffuse tracheobronchitis and pneumonitis.

Case 5. Child, aged 17 months; peanut in right main bronchus. One unsuccessful bronchoscopy before admitted. Dyspnea on admission; tracheotomy performed immediately after bronchoscopic removal of nut. Death in 2 days from bronchopneumonia.



a b c

Fig. 5. Roentgenograms made in the case of a boy, aged 9 years, who had aspirated a piece of rubber 2 years previously. Roentgenogram, a, made during March, 1936, immediately preceding bronchoscopic removal of the foreign body revealed a marked increase in the pulmonary markings particularly behind the heart shadow. b, After instillation of iodized oil into the left bronchus during July, 1939, well advanced bronchiectasis involving lower lobe of left lung was noted. Cough and expectoration of 4 to 6 ounces of pus daily. Lobectomy is contemplated.

CASE 6. Child, aged 1 year; almond kernel in right main bronchus; sojourn 10 days. Tracheotomy for dyspnea 36 hours after removal of foreign body. Death 2 days later from septic tracheobronchitis.

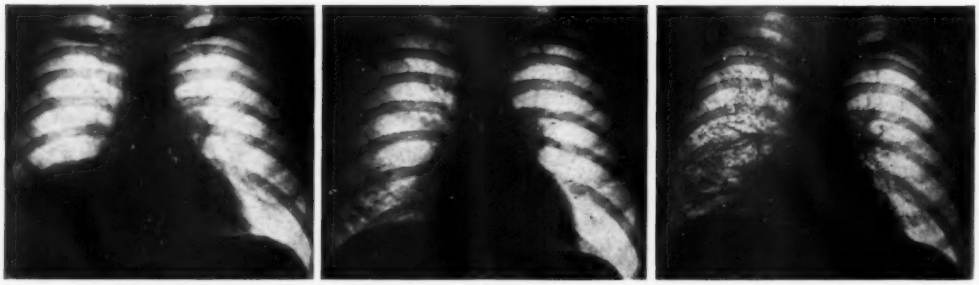
CASE 7. Child, aged 3 years; grain of corn (maize) in trachea; sojourn 7 days. Foreign body migratory; patient very dyspneic. Tracheotomy performed immediately following removal of foreign body. Developed scarlet fever 2 days later and died at Municipal Hospital on third day.

CASE 8. Child, aged 2 years; fish bone in lower end of trachea; sojourn 5 days. Unsuccessful bronchoscopy before admission. Tracheotomy for dyspnea on second day after removal of bone. Membranous exudate positive for Bacillus diphtheria. Died on third day.

CASE 9. Child, aged 19 months; bone in left main bronchus; sojourn 16 days. Tracheotomy for dyspnea following removal of bone. Ten hours later developed marked subcutaneous and probably mediastinal emphysema and died within 12 hours.

CASE 10. Child, aged 22 months; tooth migratory in trachea; sojourn 2 days. Tracheotomy necessary for dyspnea 2 hours after bronchoscopy. In about 4 hours developed subcutaneous and mediastinal emphysema and died in 14 hours.

CASE 11. Child, aged 11 months, open beauty pin in trachea; sojourn 8 days. One unsuccessful bronchoscopy before admission; marked dyspnea with cyanosis on admission necessitated immediate tracheotomy. Pin removed by bronchoscopy; death occurred suddenly 26 hours later. At autopsy the



a b c

Fig. 6. a, Roentgenogram made of man, aged 35 years, revealed atelectasis of lower lobe, right lung. There was a history of a severe choking attack and wheezing respiration after eating lamb 33 days previously. Developed pneumonia (?) which, however, did not undergo resolution. Instead developed cough with expectoration of large quantity of foul sputum, weight loss, 41 pounds, and pain in the right chest. At bronchoscopy a portion of lamb bone found completely occluding the right lower lobe bronchus was removed. b, Roentgenogram made 7 days after bronchoscopy revealed marked improvement in appearance of right lower lung. c, Roentgenogram made following instillation of iodized oil revealed moderate degree of bronchiectasis involving subdivisions of right lower lobe bronchus. Bronchoscopic treatments continued and patient practically symptom-free. (Films by Dr. K. Kornblum.)

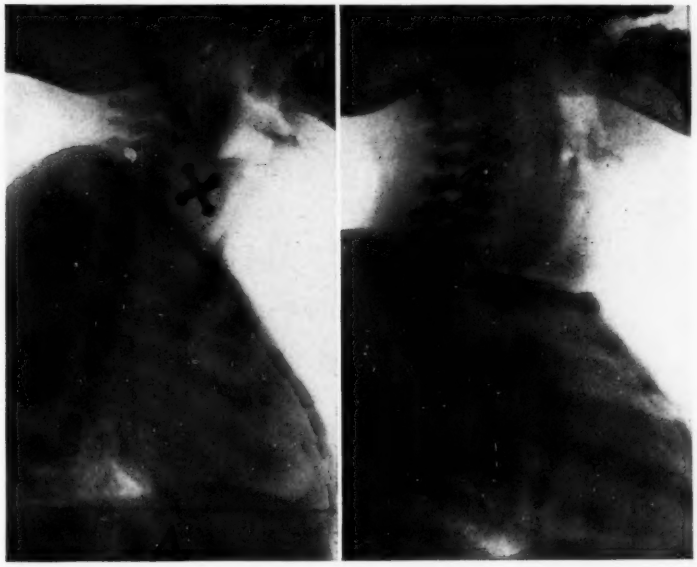


Fig. 7. a, left, Roentgenogram of child, aged 2 years, 12 days after swallowing a jackstone. There is marked peri-esophageal swelling, forward displacement of the trachea, and a suggestive air bubble immediately below the object. b, There is marked swelling of the retropharyngeal and retro-esophageal tissues with several small air bubbles. A retropharyngeal abscess was found and was drained through a perforation made by the jackstone. The patient made a very satisfactory recovery. (Films by Dr. W. F. Manges.)

cause of death could not be determined; inflammatory changes were noted in the tracheobronchial mucosa.

CASE 12. Child, aged 4 years; history of having aspirated a peanut which was removed bronchoscopically 1 week later. Tracheotomy performed following day. Two bronchoscopic aspirations later performed for removal of secretion. A roentgenographic study then made revealed bronchoscopic forceps blade in right lower lung. Unsuccessful attempt at removal made using improvised biplaned fluoroscope. On admission to clinic patient had right-sided tension pneumothorax and was very ill. Believing forceps blade might be responsible for tension pneumothorax bronchoscopic removal with fluoroscopic aid was done. Patient died following day from pyopneumothorax and multiple abscesses of lower right lung.

Of the 12 fatalities 8 were aged 2 years or less; these included 3 under 1 year. A bronchoscopic attempt at removal was made in 5 cases and in 1 case 4 bronchoscopies and tracheotomy were performed before admission. In 11 cases tracheotomy was performed either before or after bronchoscopy for obstructive laryngeal dyspnea. Three of these were done before and 8 after admission. The causes of death were acute septic tracheobronchitis with pulmonary involvement in 5 cases, mediastinal emphysema following tracheotomy in 2 cases; scarlet fever and diphtheria, 1 each; pyopneumothorax and multiple pulmonary abscesses in 1, asphyxiation in another, and in 1 no cause could be demonstrated at autopsy.

COMPLICATIONS AND SEQUELÆ OF FOREIGN BODIES IN THE FOOD PASSAGES

Complications of foreign bodies in the food passages usually result from injury produced by the foreign body, ill-advised attempts at removal, instrumentation, infection following penetration of the wall of the food passages, or perforation of surrounding structures. Occasionally, compression of the trachea results in obstructive dyspnea and may necessitate tracheotomy.

Fig. 8. Photographs of specimens of esophagus, a, left, and aorta, b, removed at autopsy by Dr. B. L. Crawford. The opening in the esophagus was found opposite the bifurcation of the trachea. The margins of the opening were necrotic. The opening in the aorta appeared ragged in outline and measured 1.75 centimeters in diameter. It was located at the junction of the arch and descending portion of the aorta and communicated with the opening in the esophagus.

Tracheotomy. In 3 instances it became necessary to perform tracheotomy for relief of dyspnea. In 2 cases one of bone and one of jackstone in the esophagus it was necessary to do tracheotomy. Both terminated fatally and will be discussed under the heading of fatalities. In a third case a jackstone in the esophagus had penetrated the party wall. Tracheotomy was performed for relief of dyspnea before the foreign body could be removed. This case will be considered under esophagotracheal fistula.

Emphysema. This complication commonly results from a break in the mucosa due to injury produced either by the foreign body or from instrumentation; it was noted in 3 cases treated endoscopically. One of these was a fatal case of bone in the esophagus to be referred to under fatalities. The second was one of toothplate in the cervical esophagus. The emphysema developed immediately following its removal. Whether it was the result of instrumentation or of previous injury by the denture could not be determined. The emphysema, limited to the neck, cleared promptly without untoward effects. In a third case emphysema of the neck developed prior to instrumentation. The patient, aged 36 years, had swallowed a large green olive 24 hours previously. It lodged in the cervical esophagus and provoked incessant gagging and retching. No additional emphysema occurred following removal of the olive and recovery was prompt.

Retropharyngeal abscess. Injury to the pharyngeal wall by foreign bodies and by well intentioned but misguided efforts at removal are common causes of cellulitis and abscess

of the retropharyngeal space. Digital attempts at removal of a swallowed or aspirated foreign body are ineffective almost always, often force the object into the larynx or hypopharynx, and frequently produce considerable tissue injury.

Many pointed objects as thumb tacks and safety pins lodging in the hypopharynx are complicated by retropharyngeal swelling. A majority of these undergo resolution without suppuration. In the cases of jackstone, several bones, and safety pins there was definite abscess formation which required incision and drainage (Fig. 7). One case terminated fatally.

Injury to the esophagus by foreign body. The wall of the esophagus may suffer superficial trauma by an irregular object; it may be penetrated by a jagged, foreign body or it may be perforated. These accidents may lead to superficial infection, abscess of the wall or of the peri-esophageal tissues, mediastinitis, and perforation into the trachea or great vessels.

Abscess of the esophagus and mediastinitis. The frequency of injury to the esophageal wall by jagged or pointed bones, open safety pins, dentures, and other irregular objects, and the continuous presence of mouth secretions should result in frequent peri-esophageal infection, mediastinitis, and death. The reverse, however, seems to be the case. This may be explained by the flexibility and elasticity of the esophageal walls, the protective barriers afforded by the peri-esophageal tissues in slowly perforating objects, and by drainage into the esophagus from the area of suppuration through the opening made by the foreign body.

It is not common to find a circumscribed abscess. However, one such case was observed.

CASE 13. A man, aged 53 years, had swallowed a pork bone 5 days previously. When admitted, he was very ill and complained of dysphagia and severe pain in the upper chest made worse by swallowing. Roentgenographic study revealed marked peri-esophageal swelling immediately below the level of the suprasternal notch. At esophagoscopy a spicule of bone, 5 centimeters in length, was removed. It was found transfixed across the esophageal lumen with the lowermost extremity imbedded in the lateral wall. When moved with forceps a large quantity of fetid pus was evacuated. The following day the temperature was normal and the patient was symptom free. Subsequent studies revealed prompt clearing up of the infection and the patient made a complete recovery.

CASE 14. In a second case of bone the patient developed a retropharyngeal abscess and mediastinitis, required tracheotomy, and terminated fatally.

Esophagotracheal fistula. Large irregular foreign bodies in the upper esophagus may ultimately, by pressure necrosis, break through the party wall and project into the trachea. One case was observed in this series.

CASE 15. A child, aged 3½ years, swallowed a jackstone 32 days before admission to the clinic. Marked dyspnea and dysphagia were present. Roentgenographic study revealed a large jackstone in the upper esophagus. There was marked peri-esophageal swelling. One point of the jackstone, extending forward into the tracheal air column, apparently had penetrated the party wall. Esophagoscopic removal was attempted but owing to increasing dyspnea a 4 millimeter bronchoscope was passed and tracheotomy was performed. One point of the jackstone was observed projecting through the posterior tracheal wall in a mass of granulated tissue. The jackstone was removed esophagoscopically. There was remarkably little disturbance with swallowing, decannulation was carried out and ultimately the patient was discharged well.

Perforation of esophageal wall and great vessels. Three cases of perforation of the great vessels were observed in this series of cases. In one, a case of safety pin in the esophagus, the point of the pin had entered the innominate artery. In the second case, the sharp point of a fish bone had eroded through the wall of the aorta, and in the third case the point of a jackstone had entered a large vessel at the root of the neck. These cases will be described elsewhere. All terminated fatally.

Cicatricial stenosis resulting from foreign body. It is not uncommon to find an esophageal foreign body lodged proximally to a stricture. The development of cicatricial stenosis of the esophagus from lodgment of a foreign body has not been observed. In several instances, particularly in cases of prolonged sojourn of a button in a child, marked stenosis resulted due to inflammatory and edematous changes. With removal of the foreign body these cleared up promptly with no appreciable narrowing of the esophageal lumen.

Fatalities. In the series of 537 cases of foreign bodies in the food passages there were 4 deaths that could be attributed to the

foreign body. There were no fatalities following instrumentation for removal of the foreign bodies. A brief résumé of the cases follows:

CASE 16. A child, aged 13 months, jackstone in esophagus at level of suprasternal notch; sojourn 24 days. Marked dyspnea on admission necessitated tracheotomy. Roentgenographic study showed tracheal compression. The condition was good following removal of foreign body until the eleventh day when there was a sudden outpouring of an enormous quantity of blood from mouth and nose. No autopsy was permitted. It was believed that the bleeding was esophageal in origin probably from erosion of a point of the jackstone into a large vessel. The tracheotomy wound appeared normal.

CASE 17. A child, aged 22 months; open safety pin in upper thoracic esophagus lying obliquely with point to left and anteriorly and imbedded in esophageal wall; sojourn 4 days. Removed by endogastric version with fluoroscopic aid. Patient discharged 3 days later. On the twelfth day after removal the patient had profuse hemorrhage and died. At autopsy a depression was found in the esophagus which communicated with an opening in the innominate artery. The point of the pin apparently had penetrated the esophageal wall and entered the artery.

CASE 18. A man, aged 47 years; gill bone of catfish in middle third of esophagus; sojourn 8 days. On admission had marked dysphagia, severe pain in chest, and some dyspnea. Bone found with both extremities imbedded in esophageal wall; marked inflammation and edema. The bone was removed and the patient died 36 hours later following profuse hemorrhage from mouth. At autopsy a large necrotic area was found in the esophageal wall which communicated with an opening in the descending aorta (Fig. 8).

CASE 19. A woman, aged 51 years; multiple chicken bones in cervical esophagus; sojourn 5 days. On admission she was found to have diabetes. There was marked dysphagia, dyspnea, painful induration of neck, and pain in chest. Four bones from neck of chicken removed from cervical esophagus. Tracheotomy was performed for dyspnea. The patient became comatose and died from retropharyngeal abscess, mediastinitis, and bronchopneumonia.

Three of the fatalities resulted from penetration of the esophageal wall, injury to one of the great vessels, and ultimately uncontrollable hemorrhage. Large, non-pointed objects as a jackstone may produce sufficient tissue destruction by pressure necrosis to accomplish this if continued for a sufficient time. Pointed objects may penetrate promptly if in close proximity to a pulsating vessel as in the case of the open safety pin and spicule of bone.

Gastric foreign bodies. Included in the foreign bodies in the food passages are 32 which were removed from the stomach by rigid tube gastroscopy with roentgenoscopic assistance. There were no fatalities nor untoward developments. With few exceptions the patients were discharged within 2 days after removal of the foreign body. Included among the foreign bodies were 11 open safety pins, 5 bobbette pins, 2 hair pins, and 8 coins. Of the safety pin cases, all were under 18 months of age, 10 being 1 year of age or less; the youngest was 2½ months. Twenty-five of the 32 patients were 3 years of age or less.

SUMMARY

A series of 950 cases of foreign bodies in the air and food passages is reviewed and complications and end-results are discussed.

Dyspnea occurred more often and tracheotomy was required more frequently in foreign bodies of vegetal origin.

Subcutaneous emphysema of the neck was observed not infrequently following tracheotomy. Subcutaneous and mediastinal emphysema may develop, however, before instrumentation or operation.

Pulmonary abscess is an uncommon complication of bronchial foreign body. Bronchiectasis, however, is often observed particularly in cases of foreign bodies of long sojourn and in complete bronchial obstruction with suppuration.

Unfavorable developments following esophageal foreign body lodgment are not as common relatively as in foreign bodies in the air passages. The common complications are injury to the esophageal wall with infection varying from traumatic esophagitis to mediastinitis. Fatal results also may occur from pressure necrosis and erosion into a large vessel or perforation of its wall.

In a series of 950 consecutive foreign bodies removed endoscopically from the air and food passages there were 16 deaths or 1.68 per cent.

In presenting this report I wish to express my personal appreciation and to pay tribute to that distinguished physician through whose life-long labors this type of work has been made possible; who created a specialty in medicine and attained the highest degree of

skill and perfection in its practice, laid down the fundamental principles governing endoscopic procedures, devised a majority of the instruments and equipment employed, and by his writings and teachings has directly or indirectly taught all who are engaged in the practice of this specialty, Dr. Chevalier Jackson, the Master Bronchoscopist.

The foreign bodies and brief notes concerning each case in this series are on file in the Mutter Museum, College of Physicians of Philadelphia, under the designation of The Chevalier Jackson Collection.

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WATER AND ELECTROLYTE BALANCE

FREDERICK A. COLLER, M.D., F.A.C.S., and WALTER G. MADDOCK, M.D., F.A.C.S.,
Ann Arbor, Michigan

PROTOPLASM is a suspension of protein in salty water of definite composition; tissue is a mass of units of protoplasm surrounded by spaces filled with salt solution. In contradistinction, fats and carbohydrates are stores of energy (40). In health these chemical relations are maintained with remarkable constancy through the metabolic reactions of the organism. In abnormal states of disease or inadequate intake of food elements these relations are disturbed and may of themselves cause untoward symptoms or even death. Frequently surgical patients are unable to eat and drink because of lesions of or operations on the gastro-intestinal tract and they likewise are subject to abnormal losses of fundamental substances and fluids; consequently, abnormalities of chemistry often require correction by the surgeon. The common, acute, chemical emergencies in the surgical patient are caused by the loss or deprivation of oxygen, blood, water, salt, and glucose. From early studies of metabolism, Rubner stated that in starvation an animal can lose practically all of its glycogen and fat, half of its body protein, 40 per cent of its total body weight, and still live; whereas the loss of 10 per cent of the water content results in serious disorder, and the loss of from 20 to 22 per cent results in death. It is our purpose to present the problem of water and electrolyte balance in a manner applicable to the surgical patient by the clinician.

WATER BALANCE IN HEALTH

In Table I, the components of water balance in health are listed and the quantities stated show a nice adjustment between available water and excreted water. The balance at first glance may seem to be too perfect, but this is exactly what happens, generally not for a single day but over several days. The constancy of the body weight of many individuals for months and years is quite remarkable considering the ingestion and excretion of kilograms of material daily. Water drunk varies considerably; figures of from 800 to 2,000 cubic centimeters daily are common. Food often furnishes as much water as fluids drunk, there being 2 sources: (1) the water content and (2) the water formed by the oxidation of the constituent proteins, fats, and carbohydrates.

On the excretory side the low loss is in the stools, in which a fine example of body economy is illustrated, namely, that although from 8 to 10 liters of various fluids pour into the upper part of the gastro-intestinal tract daily, practically all of these fluids are absorbed lower down, and barely enough remains to allow easy passage of fecal material. The two important water losses are for the excretion of waste materials in solution through the kidneys and by vaporization from the skin and lungs as part of the heat dissipating mechanism. Under comfortable environmental conditions approximately 75 per cent of the body heat is dissipated by radiation, conduction, and convection from the body surface and 25 per cent by the vaporizing process (39). The latter is the safety valve in the control of body temperature, for when there is more heat to dissipate because of physical exertion or fever or when the environment becomes hot and humid making radiation, conduction, and convection difficult, the vaporizing process becomes more active and dissipates more heat. In the extremes of temperature and humidity several liters of water may be vaporized daily. It is an important fact that the vaporizing process has "preferential rights" on available water over water for kidney function. The simplest illustration of this is the common ob-

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TABLE I.—THE COMPONENTS OF WATER BALANCE IN HEALTH

Available water	c.cm.	Excreted water	c.cm.
Water drunk.....	1,200	Water of urine..	1,200
Food, diet, or body substance			
Water content.....	1,000	Water of stool...	100
Water of oxidation..	300	Water vaporized.	1,200
	2,500		2,500

servation in hot weather during which plenty of fluids are drunk, much sweating occurs, but little urine is voided.

The kidneys are most important in maintaining the water balance. If there is plenty of available water, the urinary wastes are put out in a large volume of urine of moderate or low specific gravity. If water is scarce, the urine volume is small and its specific gravity is high. One should never forget the fact that a small volume of urine, particularly of high specific gravity, means insufficient available water.

WATER BALANCE IN DISEASE

The patient who can eat and drink should seldom be and rarely is a water balance problem, and by far his kind make up the majority of patients. The accusation has been made that too much emphasis has been placed on intravenous fluids. The emphasis, however, is right for the right patients; the intelligent surgeon never forgets that food and drink should be taken by mouth whenever possible. In some disease conditions nothing can be taken by mouth and under these circumstances about 300 to 500 cubic centimeters of water become available from the water content and the water of oxidation of body substance burned for energy requirements. This is inadequate for daily needs and unless fluids are given parenterally dehydration results, because water is being lost continually by vaporization and through the kidneys. At the University Hospital it is the custom to forget this internally provided 300 to 500 cubic centimeters and calculate the amount of fluid to meet the daily water needs for vaporization and for urine as follows: so many cubic centimeters for vaporization, and so many more for urine. The ideas as to these volumes are arrived at from the following considerations:

TABLE II.—THE MINIMUM AMOUNT OF WATER NEEDED TO EXCRETE 35 GRAMS OF WASTE MATERIALS[1]

Status of kidneys	Maximum concentrating ability Specific gravity	Minimum water needed c.cm.
Normal.....	1.032 to 1.029	483
Diseased[2].....	1.028 to 1.025	595
	1.024 to 1.020	605
	1.019 to 1.015	850
	1.014 to 1.010	1439

[1]Calculated from Lashmet and Newburgh.
[2]Chronic nephritis, pyelonephritis, renal tuberculosis, et cetera.

Water of vaporization for surgical patients who have no particular tax upon their heat dissipating mechanism, that is, patients who are in comfortable environmental conditions, who are not sweating, and whose progress is uncomplicated by fever or hyperthyroidism, varies from 1,000 to 1,500 cubic centimeters daily (8), which is approximately a normal amount (41). The 1,000 cubic centimeters is for the smaller, less active individuals, while the 1,500 cubic centimeters is for the larger, more vigorous persons. Patients whose course is complicated by an increased demand on the heat dissipating mechanism through fever, hyperthyroidism, or hot, humid weather vaporize more than the normal, and for these a minimum of 2,000 cubic centimeters daily is allowed as a starting figure (32). With the extremes of fever or hot, humid weather more water may be needed for this heat dissipating process.

The second important daily water loss, that of the urine output, can be controlled largely by the physician, for water given over and above the amount used for vaporization is excreted as urine. What is the minimum amount of urine below which one should be concerned, and what is a satisfactory urine output? Lashmet and Newburgh have furnished these data by determining the minimum amount of water needed by individuals with normal and diseased kidneys to excrete body wastes. From their work a calculation was made of the minimum amount of water needed to excrete 35 grams of waste material, which is about an average daily amount. This calculation is given in Table II, and from it one can see that about 500 cubic centimeters of urine a day is a minimum for the daily excretion of waste materials. It is not a satis-

TABLE III.—THE DAILY WATER REQUIREMENTS OF THE SURGICAL PATIENT

	c.cm.
Uncomplicated case	
Water for vaporization	1,000 to 1,500
Water for urine	1,000 to 1,000
	2,000 to 2,500
Complicated case: fever, hyperthyroidism, hot humid weather	
Water for vaporization	2,000 to 2,000
Water for urine	1,000 to 1,500
	3,000 to 3,500

factory output of urine because it is only sufficient when the kidneys are working at their maximum concentrating capacity, as shown by the specific gravity of the urine being close to 1.030. Also, experience with several water balance problems have substantiated the view that when 500 cubic centimeters of urine with a specific gravity close to 1.030 are being put out daily, the supply of available water is low and actually some patients with such a urine excretion may be dehydrating. We do know from the data of Table II that with volumes of urine appreciably below this amount, particularly when their specific gravity is low, one can expect retention of waste materials as shown by an increasing blood non-protein nitrogen which results.

In round figures, 1,000 cubic centimeters daily is recommended as a good urine output for the majority of surgical patients. Wangensteen and his associates consider from 700 to 1,000 cubic centimeters satisfactory. White, Sweet, and Hurwitt (54) look for a urine output of from 800 to 1,000 cubic centimeters per day for neurosurgical patients, and Graham maintains a water balance in patients needing surgical procedures for gastric or duodenal ulcer that provides 900 cubic centimeters of urine daily. As can be seen from Table II, these figures cover approximately twice the minimum volume and the upper brackets of diseased kidneys. For the seriously ill patient, particularly those with sepsis, with severe biliary tract disease, or with some renal impairment from any cause, a water intake that provides at least 1,500 cubic centimeters of urine daily is often desirable. For special reasons more urine may be needed.

The water requirements for vaporization and urine are summarized in Table III. The figures of from 2,000 to 2,500 cubic centimeters daily are ample for a great many patients who for one reason or another cannot take fluids by mouth. For those with complications, from 3,000 to 3,500 cubic centimeters daily may be necessary. In Table III the requirements are simply broken up into their component parts of so much for vaporization and so much for urine in order that one can deal with them independently according to the needs of the patient. For example, Wassel in our laboratory showed that during hot, humid weather the vaporization loss in a group of general surgical patients amounted to from 2,068 to 5,034 cubic centimeters daily. It is quite apparent that if parenteral fluids were necessary for such patients, an allowance of 2,000 cubic centimeters for vaporization would fall short and water given for kidney function would be taken for vaporization; the result would be an insufficient urine output. Variations, therefore, in the needs of patients under special conditions must always be kept in mind.

The kind of fluid to give if parenteral administration is necessary to provide water for vaporization and for urine is 5 or 10 per cent dextrose in distilled water. The reasons for this selection are based on studies which have shown that these solutions when administered intravenously at the rate of 300 to 500 cubic centimeters per hour are handled by the body the same as if they were given by mouth (7). Very little of the dextrose is spilled in the urine; the majority is rapidly oxidized or stored as glycogen, and the water of the solution becomes available for all purposes (55).

Is it safe to give only dextrose and water to some patients? This is a question often asked and which is not difficult to answer. Water given intravenously as 5 per cent dextrose in distilled water does not wash out appreciable amounts of sodium chloride through the kidneys (7) unless an excess of this electrolyte is present. So one does not need to fear appreciable losses of salt in this way. With vaporization there is little loss of salt in most surgical patients. But to provide for these minor elec-

trolyte losses, it is our custom to give 500 cubic centimeters of Ringer's solution daily to patients whose chief need is water for vaporization and water for urine, and who are receiving dextrose solution in water for that purpose.

Abnormal losses of fluid from the body, such as by vomiting, are common among seriously ill surgical patients, and result in both a loss of water and the substances in solution in that water. Among the latter, the electrolytes are very important and the chief of these is sodium chloride. An understanding of sodium chloride metabolism, how it is affected in surgical disorders, and its management in such conditions is necessary. Recently, a comprehensive survey of the salt balance in surgical patients was made by Nadler and by our associates, Bartlett, Bingham and Pedersen.

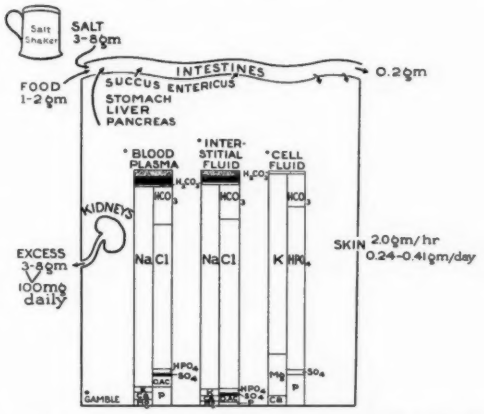

Fig. 1. A diagrammatic presentation of sodium chloride metabolism.

NORMAL METABOLISM OF SODIUM CHLORIDE

The importance of sodium chloride to the body is well illustrated in Figure 1, where the central diagrams of Gamble (17) show the predominance of sodium as the chief base and chloride ions as the chief acid radicals in the composition of the blood plasma and interstitial fluid. In cellular fluid these places are taken by potassium and phosphates. Sodium chloride in the extracellular fluids serves 2 vital functions: (1) it helps to maintain the acid-base balance of the body, and (2) it is largely responsible for the osmotic pressure of the various fluids. The total amount of electrolytes present is importantly concerned with the maintenance of the normal volume of extracellular fluid, since it is a fundamental axiom that the body keeps its substances in solution at approximately a constant concentration. Sodium has a greater rôle than chloride ions in the maintenance of the extracellular fluid volume (18), since the latter can be replaced by bicarbonate made up from the carbon dioxide of catabolism, while there is no substance to take the place of sodium. If sodium is depleted, water must be lost to keep the concentration of the substances in solution at the normal level. Dehydration thus follows sodium depletion more than chloride loss.

Figure 1 also shows diagrammatically the normal metabolism of sodium chloride. From the total intake of 3 to 10 grams daily the largest portion comes from the vigorous use of the salt shaker as taste demands; the natural content of sodium chloride in the food is not much more than 1 to 2 grams per day (43). Along with this oral intake of salt the upper part of the gastro-intestinal tract receives through saliva, gastric juice, succus entericus, bile, and pancreatic juice about 8 to 10 liters of salt containing fluids daily. This is another remarkable example of body economy, namely, similar to the conservation of water practically all of the salt is later absorbed; the sodium chloride loss in the stool is reported at about 0.2 grams per day (51). The loss of salt from the skin is variable. With insensible perspiration Freyberg and Grant found values from 0.25 to 0.41 gram per day, which are negligible. With active sweating more salt is lost (14); upper limits under extremes of work, heat, and humidity are reported as high as 2.0 grams per hour (37). The kidneys excrete the excess sodium chloride remaining after the stool and skin losses have been deducted from the oral intake. In this way the normal sodium chloride balance is maintained.

At this point it should be understood that while the kidneys normally excrete the excess of salt, they conserve salt and excrete meager amounts, as low as 0.1 gram per day when there is no excess, or even a deficit because of an abnormal loss of salt as by vomiting.

Benedict followed the chloride excretion in the urine of a subject fasting for 31 days and found that 12.3 grams of chlorine or 20.3 grams of sodium chloride were put out during that time. Half of this amount, however, was put out in the first 4 days; during the later days only traces of chloride in the urine could be shown. This same protection of the electrolytes when the intake is insufficient has been observed by many workers (52, 53, 19). It applies to individual ions, and their conservation or excretion according to needs is an important function of the kidney.

The total amount of sodium chloride in the body has been estimated by various investigators. Calculating on the basis of a 60 kilogram man the figures of Magnus-Levy give a total sodium chloride content of 121.7 grams; those of Lotka, 158.4 grams; White and Bridge (52), 150 grams; and Sherman, 148.8 grams.

ABNORMAL SALT LOSSES

The sodium chloride metabolism of seriously ill patients may be profoundly affected. For various reasons there may be no intake of water or food by mouth, so that no new salt becomes available. To make matters worse there may be abnormal losses of salt from the body and of all such channels, vomiting and diarrhea are by far the most common. Less often drainage from the intestinal and biliary tract through tubes and fistulas, copious wound secretions, withdrawal of considerable volumes of ascitic fluid, and prolonged sweating carry away important amounts of water and electrolytes. Gamble and his associates have shown that the gastro-intestinal secretions have essentially the same electrolyte materials, but with some differences in their various concentrations. Since the losses from the gastro-intestinal tract are most important in dealing with surgical patients, it is imperative to know more about these differences that exist when fluid is lost from different portions of the tract, and how these losses are reflected in the two blood chemistry tests commonly carried out.

Chloride loss is shown by plasma chloride determinations; the normal value as expressed in the commonly accepted terms of sodium chloride is 560 to 630 milligrams per 100 cubic centimeters (43). For our calculations the lower limit of 560 milligrams per 100 cubic centimeters is used. Sodium loss or total base loss is impractical to determine directly because the chemical procedure is too time consuming. As a substitute a fair indication of total base concentration is obtained from a measurement of the plasma carbon dioxide combining power, which shows the amount of base in excess of strong acid or, for practical purposes, the amount of sodium in excess of chloride ions. There is practically always an excess of base and the normal value of the carbon dioxide combining power is 55 to 65 volumes per cent (43). If chloride is lost in excess of sodium, with more base remaining, the plasma carbon dioxide combining power is elevated, 75 or more volumes per cent, and a condition of alkalosis exists. If sodium is lost in excess of chloride, with the base having the greatest reduction, the plasma carbon dioxide combining power is lowered to 50 or less volumes per cent, and a condition of inorganic acidosis is present. It is important to remember that the plasma carbon dioxide combining power is a measurement of the base concentration relative to the acid concentration at the time of the test. A normal or even an increased plasma carbon dioxide combining power, obtained when plasma chlorides are materially lowered, indicates that some sodium has also been lost. An important practical point which will be stressed later is that fluid lost by vomiting or by removal through suction from the upper part of the gastro-intestinal tract usually carries with it a loss of chlorides greater than and rarely equalled by the loss of sodium. A calculation, then, of the proper amount of saline solution to give on the basis of the chloride loss for practical purposes provides for the sodium loss as well.

In Figure 2 a schematic presentation is given of the fluid from various portions of the gastro-intestinal tract and its acid or base predominance. The causes for the loss of such fluid and its effect on the plasma chloride and carbon dioxide combining power are discussed briefly as follows:

Pyloric obstruction. Obstructing lesions of the pylorus in infants are commonly the result

of congenital hypertrophic stenosis and in adults are due usually to carcinoma of the stomach or scar contraction from long-standing peptic ulcer. The fluid loss is predominately acid. The result is a lowered plasma chloride and a relative increase in plasma base as shown by an increase in the carbon dioxide combining power of the blood. Here one has an opportunity to see the typical picture of alkalosis.

Bile drainage. Surgical drainage of the common bile duct often leads to the loss of several hundred cubic centimeters of bile a day, with a consequent greater loss of base than acid ions. Generally the drainage is insufficient for serious depletion of electrolytes, but occasionally it is, and one finds a slight to moderate reduction in plasma chlorides and a somewhat greater depletion of base as shown by a lowered plasma carbon dioxide combining power. The loss of several liters of bile for several days will result in severe electrolyte depletion, and because the sodium loss is great the dehydration also will be great.

Duodenal or jejunal obstruction. The vomiting of fluid from even as low down as the mid-ileum results in the loss of a complex fluid containing saliva, gastric juice, bile, pancreatic juice, and succus entericus. As can be seen in Figure 2, some of these fluids have more chloride than base while others have more base than chloride. The sum is a loss of about equal amounts of chloride and base, so chemistry studies usually show a reduced plasma chloride and a nearly normal plasma carbon dioxide combining power which, being relative to the chloride concentration at time of test, indicates a lowered amount of base.

Ileostomy drainage. Here base loss predominates and with considerable semi-fluid or fecal drainage or with moderate drainage for many days one finds a slight to moderate reduction in plasma chlorides and a considerably lowered plasma carbon dioxide combining power. Such drainage is a common cause of inorganic acidosis in surgical patients, and since the chemical disturbance may be quite marked, patients with an ileostomy require close supervision. Recently this matter has been well presented by Welch, Masson and Wakefield.

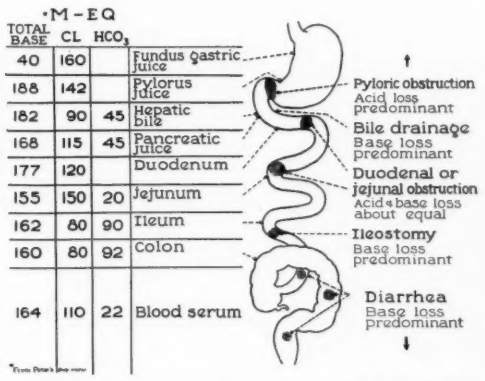

Fig. 2. A schematic presentation of the fluid from various portions of the gastro-intestinal tract and its acid or base predominance.

Diarrhea. The tremendous loss of body fluid and substance which can result from diarrhea and dysentery has been recognized for many centuries, and O'Shaughnessy, in 1832, knew that the effluvia was alkaline and its loss reduced the body base. The pediatricians have been particularly concerned with this problem and the chemical studies in this regard by Gamble and his associates (17) are of fundamental importance. Because of the extra base loss, Hartmann has advocated the use of sodium lactate solutions, which, since the lactate is oxidized, provides an excess of base. Diarrhea and dysentery are not commonly associated with surgical lesions, so they will not be discussed further in this paper.

It would seem that correction of all these different fluid losses with their variations in the amount of base or acid present would be most complicated and difficult. Gamble (17), however, has emphasized the fact that whether an alkalosis or inorganic acidosis is present both can be corrected by a combination of the same two solutions: (1) isotonic saline solution which provides water and the chief electrolytes needed, and (2) dextrose solution which provides an excess of readily available water for kidney function. Whether more chloride is needed than sodium or vice versa, the kidneys with a good supply of water can be depended upon to use this water for the excretion of the less needed electrolyte. The

TABLE IV.—THE EXCELLENT EXCRETION OF AN EXCESSIVE INTAKE OF SODIUM CHLORIDE BY A NORMAL ADULT MALE

24 hour period of study	Body weight kg.	Sodium chloride intake Ringer's solution			Sodium chloride in urine gm.	Plasma chloride mg. per cent	Plasma carbon dioxide combining power volume per cent
		diet gm.	solution gm.	total gm.			
	50.5					545	52.0
1	50.6	3.3	28.6	31.9	21.1	548	57.1
2	50.5	2.2	0.0	2.2	9.2	543	55.2
Totals		5.5	28.6	34.1	30.3		

interplay of these two solutions, one providing the water and the electrolytes needed to correct dehydration and the other adequate water for kidney function, is most important.

The discussion of abnormal salt loss firmly establishes the reasons for the administration of saline solution to some patients. Past experience reveals that generally too much salt solution has been given without regard to whether sodium chloride is needed or not. Such thoughtless treatment is harmful and the whole subject of excessive salt intake needs thorough understanding.

EXCESSIVE SALT INTAKE

An important step encouraging the use of intravenous fluids was the demonstrated value of saline solution as a life saving measure for animals with intestinal obstruction. The investigations of O'Shaughnessy, Hartwell and Hoguet, MacCallum and his associates, Haden and Orr, Gamble and Ross (18) and many others (2) definitely established the value of saline solutions for patients who have lost appreciable amounts of body electrolytes. The tendency after this work, however, was to give salt solution to all patients needing fluids parenterally whether they had lost salt or not. This procedure results many times in the administration of excessive amounts of sodium chloride, and an understanding of its handling by various types of individuals is important.

Excessive amounts of salt in normal individuals. Normal individuals can handle 35 to 40 grams of sodium chloride daily without apparent difficulty, for the kidneys are able to excrete the salt in urine in concentrations up to 2 per cent (43). In Table IV this is demonstrated by the data from excessive salt administration to one of our normal subjects. Note that there was no retention of water as shown by no change in weight, that 30.3 grams of the 34.1 grams of salt ingested in the 2 days were excreted in the urine, and that the plasma chloride and carbon dioxide combining power were essentially unchanged.

Excessive amounts of salt to patients in good general condition. There are many patients in this category who receive fluids parenterally for a day or two after an operation because they are upset for one reason or another and cannot take fluids by mouth. They are healthy

TABLE V.—THE SATISFACTORY EXCRETION OF AN EXCESSIVE INTAKE OF SODIUM CHLORIDE BY A PATIENT IN GOOD GENERAL CONDITION[1]

24 Hour period of study	Body weight kg.	Sodium chloride intake from physiological saline solution gm.	Sodium chloride in urine gm.	Plasma chloride milligram per cent	Plasma carbon dioxide combining power volume per cent
	68.2			589	57
1	69.4	27.8	11.4		
2	68.4	26.0	29.2		
3	67.0	15.3	12.3	565	53
Totals		69.1	52.9		

[1]Study began a few hours after the operative repair of a left inguinal hernia.

except for some local lesion before their operation and are essentially healthy after the operation. Their ability to handle excessive amounts of sodium chloride almost as well as does the normal subject is shown by the data in Table V in which an adult male in 3 immediate postoperative 24 hour periods was able to excrete 52.9 grams out of 69.1 grams of sodium chloride given. The possible dangers of saline solution are not apparent in this group, but the choice of salt solution for them is a poor one. There is no particular value in saline solution when sodium chloride is not needed, and the kidneys of these patients have the extra load of excreting the excess salt. If nothing can be taken by mouth, what this group of patients chiefly requires parenterally is water and some carbohydrate, which is provided by dextrose solution in water.

Excessive amounts of salt in the sick surgical patient. Matas, in 1924, published one of the earliest papers on intravenous therapy in this country and pointed out that large amounts of salt solution may do harm, may produce degenerative changes in heart muscle and kidneys, and may cause edema of the lungs. In 1933, Jones and Eaton (24) stressed this point further by a review of 34 cases of subcutaneous edema seen after operation. Five of their patients also had edema of the lungs, and 1 died from obstruction due to edematous closure of a gastro-enterostomy stoma. Twenty-one of the 34 patients in the series had lesions of the gastro-intestinal tract such as peptic ulcer, gastric malignancy, or perforated appendix. In the production of the edema a low serum protein consequent to undernutrition was considered to be most important, while other factors were the administration of excessive amounts of fluid and salt, profuse surgical drainage, the general effects of sepsis, the loss of serum protein by massive hemorrhage, and a retention of base due to temporary disturbance of renal function. Jones, Eaton, and White (25) later produced experimental edema in cats, substantiated the importance of the above factors in its production, and added those of major surgical procedures and general anesthesia. These factors leading to retention of water will be mentioned again later.

Intravenous fluids are commonly used for patients with shock and there is every need for their selection on the basis of results. Beard and Blalock studied the composition of the blood of dogs undergoing continuous trauma to the intestines (1) when no fluid was injected, and (2) when fluid was injected continuously. A copious weeping of fluid from the peritoneal surface resulted from the trauma. This fluid had the same protein content as that of the blood plasma and the result was a loss of plasma proteins, and, therefore, a diminished osmotic pressure of the blood. The effects of the injection of various fluids on the reduced protein content of the blood of these dogs, which were in shock, are most important. With the continuous injection of 0.9 per cent salt solution there was a decrease in the total volume of blood plasma and a marked reduction in the percentage of protein per unit volume of serum; the calculated entire amount of protein in the blood stream was generally one-half of the original values. It was the impression of Beard and Blalock that if the injection of salt solution was stopped the blood pressure of the animals fell more rapidly than if no intravenous fluid had been given. The results were no better with 3.0 and 6.0 per cent saline solution. From these experiments one can expect little from the treatment of moderate or severe shock due to blood plasma loss by the use of physiological saline solution. Beard and Blalock state "that they do not wish to imply that if a patient is in shock as a result of an injury and no donor is available that saline or similar solutions should not be injected. However, in the absence of a favorable response in blood pressure after a considerable amount of solution had been injected, almost certainly the further administration of the same fluid intravenously would diminish the chances of recovery."

A further warning against the excessive administration of salt solution to seriously ill surgical patients comes from the study of White, Sweet, and Hurwitt (54) on the water balance of neurosurgical patients, a study which was carried out in order to be able to maintain such patients in a slightly dehydrated condition and thus avoid edema of the

TABLE VI.—DATA ILLUSTRATING THE DIFFERENCE IN THE ABILITY OF A PATIENT TO EXCRETE AN EXCESSIVE INTAKE OF SODIUM CHLORIDE WHEN IN POOR GENERAL CONDITION BECAUSE OF SEPSIS AND LATER WHEN WELL

Date November	Physiological saline solution intravenously		Output urine		Body weight	
	c.cm.	gm. NaCl	c.cm.	gm. NaCl	66.6 kg.	Change
Patient Septic						
25	2890	25.5	730	2.5	67.3	+0.7
26	2995	27.3	1466	13.1	68.3	+1.0
Totals	5885	52.8	2196	15.6		+1.7
Patient Well						
December					65.9	
18	2973	25.3	2468	12.1	64.7	−1.2
19	3477	29.6	2542	24.5	64.0	−0.7
Totals	6450	54.9	5010	36.6		−1.9

S. G. Age 59. Admitted Nov. 24 with acute suppurative olecranon bursitis. Fever to 102.6 degrees F. Given 5 per cent dextrose in physiological saline solution when septic and later when well.

brain. They state that "edema from too much salt solution is a very real danger. For this reason we recommend limiting the use of glucose in saline to the period of operation, during which there is a considerable loss of sodium chloride. Thereafter, fluids can usually be taken by mouth in adequate volume by neurosurgical patients. Saline solution should only be used when serum electrolytes are seriously depleted by prolonged vomiting or diarrhea, and then in limited amounts." In summary they state: "Postoperatively fluid must be replaced much more accurately in neurosurgical than in general surgical patients. While the latter may be given a moderate excess of fluid with impunity, a slightly deficient state of hydration is safer after operation on the brain, in order to minimize cerebral edema. In the absence of vomiting or diarrhea, five per cent glucose in distilled water appears to be a better solution for prolonged intravenous medication than when combined with normal saline, because the addition of saline increases the risk of edema." This is sound advice and has wide application considering the great number of craniocerebral injuries now due to automobile accidents.

The ease with which salt solution is retained by the sick surgical patient was further demonstrated by Coller, Dick and Maddock (7), who selected such a group of patients and gave them daily by the intravenous route about 3,500 cubic centimeters of 5 per cent dextrose in either physiological saline solution or Ringer's solution. Twelve of the 13 patients in the series retained water and gained weight although they were receiving insufficient calories and should have lost weight. One patient gained 7.5 kilograms and showed edema of the dependent parts. Only 3 of the 13 patients in the series had plasma proteins down to the critical level of Moore and Van Slyke at which edema is likely to appear. In contradistinction to the normal subject and the patient in good general condition, the sick surgical patient is less able to excrete the excess sodium chloride given but adds it with water to his body fluids. This difference between the sick and the well patient reaction is shown in Table VI in which the same patient with approximately the same intake of salt on the 2 occasions retains most of it with water and gains weight when he is sick because of sepsis, and later is able to excrete most of it and does not retain water when he is well.

It is important to emphasize that the sick surgical patient is the patient with the factors which have been pointed out by Jones and Eaton (24) and others (5, 7, 10, 35, 50) as setting the background for the development of edema, namely: nitrogen starvation with its consequent low serum protein, general malnutrition, sepsis in all its aspects, hemorrhage, profuse serous drainage, renal, and hepatic

damage. But even with these present it takes water and particularly sodium ions for edema to develop (28, 49). The general evidence is that the greater the severity of the predisposing factors, in other words the greater the sepsis or general malnutrition or the lower the serum proteins, the less salt solution it takes to produce edema. Mecray, Barden and Ravdin have emphasized that this visible edema is but an external manifestation of a complete body edema with harmful effects on internal organs. They showed that the emptying time of the normal stomach or after a gastro-enterostomy was slowed in dogs with edema due to low plasma proteins and as the plasma proteins returned to normal the emptying time improved. Ravdin and his associates have rightly stressed the need for restoring depleted plasma proteins in surgical patients; the therapeutic procedures are blood transfusion, salt restriction, administration of acacia, and a high protein diet. The last is by far the most effective and should be started as early as possible in the course of the disease.

The common error of giving excessive amounts of salt solution to surgical patients is one to avoid. Studies in our laboratory (2, 6, 7) and the observations of DeWesselow show that the plasma chloride level cannot be used as an index of excessive salt administration, since the result of salt retention is edema rather than hyperchloremia. In fact, one may find hypochloremia associated with edema. The pernicious practice of administering excess salt solution shows a lack of appreciation of the needs of the patient. The excess sodium chloride administered may easily amount to from 30 to 80 or more grams which must be excreted by the kidneys. If edema supervenes, it is known to impair function, to cause pulmonary edema, to produce hydrothorax and thus embarrass the lungs, and to increase the total body fluid volume. The surgical staff may well feel guilty in some instances when patients come to autopsy with water-logged tissues.

THE QUANTITATIVE REPLACEMENT OF ELECTROLYTES

In previous paragraphs the need for electrolytes by some patients and the dangers of excess administration have been presented. The solution to the problem is a quantitative administration that supplies sufficient and avoids an excess. From a series of studies at the University Hospital a simple working plan has been developed for maintaining a proper balance.

For practical purposes the patients requiring electrolytes can be divided into 2 groups: (1) those with normal electrolytes to begin with, but who while in the hospital lose electrolyte containing fluids through vomiting, gastroduodenal suction, biliary or enterostomy drainage, et cetera, and (2) those patients with depleted electrolytes as a result of electrolyte fluid loss before admission to the hospital. There is, of course, some overlapping of these groups, since a patient who has been vomiting before admission to the hospital may continue to vomit while in the hospital, but then the 2 methods of treatment are simply combined and used as needed.

The first group of patients always have their electrolyte fluid losses measured. If vomiting occurs after operation more than 2 or 3 times, gastroduodenal suction is started and the drainage is collected. If gastroduodenal suction is used to decompress a distended bowel, is started to forestall vomiting, or to keep the stomach or intestines decompressed after gastric or intestinal operations, the amount of drainage is measured. The output of bile from biliary tract tubes is carefully collected, as is also the drainage from enterostomies. Suction is applied to active intestinal fistulas and the drainage is measured. These procedures are not difficult or impractical. They require some organization of methods on the surgical service and when once set up they run very satisfactorily under the control of the nurses and internes. From such records on the patient's chart one knows how much fluid is lost. In Table VII the fact is shown that these fluids always have less sodium chloride per liter than does physiological saline solution or Ringer's solution. Occasionally, restoration of the electrolytes can be cared for by the oral administration of sodium chloride, hydrochloric acid, ammonium chloride, or sodium bicarbonate (51), and it is useful to know that the sodium chloride of the

TABLE VII.—THE CONCENTRATION OF SODIUM CHLORIDE IN VARIOUS FLUIDS

	Variation in sodium chloride concentration gm. per liter	Average sodium chloride concentration gm. per liter	References
Vomitus	1.2 to 6.2	3.3	(13)
Gastroduodenal drainage (Wangensteen suction)	1.9 to 7.9	5.7	(2)
Hepatic bile	3.5 to 6.4	5.1	(2)
Intestinal fistula drainage	3.1 to 6.6	5.2	(2)
	4.7 to 7.9		(51)
	3.0 to 8.8		(26)
Diarrheal stools	3.7 to 5.2	4.3	(2)
Physiological saline solution		8.5	U. S. P.
Ringer's solution		9.0	U.Mich.Hosp.
Ringer's solution		7.0	Abbott Lab.

fluid losses averages about 5 grams per liter. It is apparent from Table VII that if parenteral therapy is needed and one replaces the fluid loss with an equal volume of Ringer's solution that an adequate replacement of the water and the predominant electrolyte loss will be made (13, 32). This volume-for-volume replacement is the fundamental procedure carried out in this group (2, 6), 2 secondary ideas being incorporated. The first of these is that on the day a gastroduodenal suction is started, 1,000 cubic centimeters of Ringer's solution is given during the first 24 hours in order to lessen an initial depletion of electrolytes during this period. This liter of Ringer's solution is not counted in the volume-for-volume replacement, and for the second 24 hours the amount of Ringer's solution given equals the amount of gastroduodenal drainage for the first day. This volume-for-volume replacement then continues with the addition of the second idea, which is that a minimum of 500 cubic centimeters of Ringer's solution is given daily even if the drainage for the preceding day is less than that amount. This comparatively simple procedure maintains a very satisfactory electrolyte balance in patients losing appreciable amounts of electrolyte containing fluids while under observation. It is working well in the hands of the staff members on the surgical service and requires no special supervision. Blood chemistry studies are done at irregular intervals on such patients, the staff has learned that with the proper carrying out of the procedure the electrolyte chemistry is almost invariably normal. Failures to maintain normal plasma electrolyte concentrations with the volume-for-volume replacement have been due to failures to know the actual volume losses or to give the proper volume replacement.

TABLE VIII.—CALCULATIONS OF SODIUM CHLORIDE REQUIREMENTS FROM THE CLINICAL RULE[1]

Weight kg.	Initial plasma chloride level mgm. per cent	Calculation
60	460	1.0 by 0.5 by 60=30.0 gm.
60	410	1.5 by 0.5 by 60=45.0 gm.
50	500	0.6 by 0.5 by 50=15.0 gm.
70	360	2.0 by 0.5 by 70=70.0 gm.
45	440	1.2 by 0.5 by 45=27.0 gm.

[1]For each 100 milligrams that the plasma chloride level needs to be raised to reach the normal (560 milligram per cent), the patient should be given 0.5 gram of salt per kilogram of body weight.

The second group of patients, those with depleted body water and electrolytes as a result of electrolyte fluid loss previous to admission, usually need a substantial amount of Ringer's solution to restore their water and electrolyte composition to normal. To do this in a quantitative fashion a clinical rule was developed (2, 6) which states that "*for each 100 milligrams that the plasma chloride level needs to be raised to reach the normal (560 milligrams per cent), the patient should be given 0.5 gram salt per kilogram of body weight.*" This use of the plasma chloride level as a guide for both chloride and sodium replacement has been a satisfactory procedure in dealing with the electrolyte fluid losses of general surgical patients because such losses are mainly from the upper half of the gastro-intestinal tract and consequently the chloride loss is usually greater than and only occasionally equalled by the sodium loss. As mentioned previously, the kidneys with a good supply of water for their function are able to excrete the excess of the less needed ion and to conserve the one mainly required. Examples of the use of the clinical rule in calculating the amount of sodium chloride needed in hypothetical cases are given in Table VIII. The essential data are the patients' weight, which can be approximated if it is not known, and the plasma chloride level. For those determining whole blood chloride instead of plasma chloride the clinical rôle is slightly different (2).

Further experience with the clinical rule has brought out 3 important considerations (44).

The first of these is that the rule provides sufficient salt to restore electrolytes to normal if the body handles it normally. The second point is that the best response to the salt administered, which is a prompt return of the plasma chlorides and carbon dioxide combining power to normal and an appreciable excretion of salt in the urine showing that the balance is a positive one, occurs in patients who have not been ill for long and are in at least a fair general condition, but have suffered a recent or acute loss of electrolyte containing fluid. Such patients are mainly those with the acute causes of intestinal obstruction. The third point concerns patients who fail to have their plasma chlorides return to normal with the salt administration. These patients have a more chronic illness and the saline solution is utilized in an abnormal manner which is often quite obvious, such as edema formation in dependent parts of the body, or ascites. These patients usually have one or more of the previously mentioned causes for abnormal water and salt retention, that is, general malnutrition, low plasma proteins, sepsis, hemorrhage, profuse serous drainage, or severe hepatic or renal disease. Carcinoma of the gastrointestinal tract is a common lesion in this group, as is also severe sepsis. When given the amount of saline solution calculated as necessary from the clinical rule, the plasma chlorides do not reach normal, but an abnormal distribution of the water and salt occurs. If these patients improve clinically, their fluid and salt are readjusted and the plasma electrolytes approach normal. Experience has shown us that giving more salt than that calculated from the clinical rule is absolutely useless in increasing plasma chlorides, and also that it only aggravates the abnormal distribution of fluids. Years ago it was recognized that plasma chloride levels in patients with pneumonia often remained well below normal despite adequate intakes of sodium chloride, and that improvement occurred several days after the crisis (43). In his investigations of burned patients, Davidson often found plasma chlorides decreased in the face of a good ingestion of salt. Nothing is surprising then about the abnormalities of sodium chloride metabolism in the general run of sick surgical patients.

For the occasional case encountered among surgical patients in which the sodium loss is appreciably greater than the chloride loss special consideration is needed. Two recent examples requiring parenteral fluids were, first, in a patient with marked drainage from an ileostomy done because of chronic ulcerative colitis, and second, in a patient with prostatism and kidneys damaged to the extent of being unable economically to regulate salt and water output. Both patients had a low plasma chloride and carbon dioxide combining power and were given Lactate-Ringer's solution (22); the amount was calculated from the use of the clinical rule. From plasma chemistry determinations both were found to have made a good adjustment of their electrolyte deficiency.

USE OF COMMON INTRAVENOUS SOLUTIONS

Previous paragraphs have dealt with the water and electrolyte needs of surgical patients and it is proper to emphasize further that the choice of solution to be used depends upon the needs of the individual patient.

Five or 10 per cent dextrose solutions provide carbohydrates for energy requirements, for glycogen formation, and for the oxidation of ketone acids if they are present, and there is left a ready supply of available water. Thus, these solutions are suitable for patients who do not need electrolytes but require carbohydrates and water for vaporization and kidney function. It is our custom to use the 5 per cent solution for most patients, reserving the 10 per cent dextrose for those needing larger amounts of carbohydrates, such as individuals with cachexia, hyperthyroidism, or liver damage. Although excellent in their proper place, dextrose solutions fail to relieve or prevent dehydration in patients having lost or losing important amounts of electrolyte containing fluids. We (2, 6) and others (1) have observed the complete clinical picture of severe electrolyte deficiency, namely, lassitude, weakness, drowsiness, anorexia, nausea, muscle cramps, dehydration, and finally shock, from the error of giving dextrose solution in water when a saline solution was needed. Prompt recovery has followed correction by the suitable fluid.

Physiological saline solution or Ringer's solution have the materials for the correction

TABLE IX.—A CALCULATION OF THE FLUID NEEDED TO CORRECT THE WATER AND ELECTROLYTE BALANCE OF A DEHYDRATED PATIENT

	c.cm.
5 per cent dextrose in distilled water 3,500 c.cm. for:	
Water of vaporization	2,000
Water of urine	1,500
Ringer's solution from clinical rule for:	
Correction of dehydration	5,000
Total	8,500

of dehydration and can restore both the fluid and the electrolytes needed. Because there seems to be less abnormal retention of water when Ringer's solution is given to seriously ill patients than when physiological saline solution is given, and because Ringer's solution contains small amounts of potassium and calcium besides sodium and chloride ions (7, 15), we believe it is preferable for the correction of dehydration and electrolyte loss.

In order to summarize the use of dextrose and saline solutions Table IX presents a calculation of the fluid needed to correct the water and electrolyte balance of a hypothetical case of dehydration. The patient has been septic and sick for several days and has been vomiting. Laboratory studies show plasma chlorides of 410 milligrams per 100 cubic centimeters plasma carbon dioxide combining power 47 volumes per cent, non-protein nitrogen 40 milligrams per 100 cubic centimeters. The patient's weight is about 60 kilograms. The calculation of the amount of Ringer's solution needed to correct the dehydration was made from the clinical rule, "for each 100 milligrams that the plasma chloride level needs to be raised to reach the normal, or 560 milligrams per cent, the patient should be given 0.5 gram of salt per kilogram of body weight." The figures for the increase of from 410 to 560 milligrams are 1.5 by 0.5 by 60 = 45 grams of sodium chloride (Table VIII). The Ringer's solution used at the University Hospital contains approximately 9 grams of sodium chloride per liter, so 5 liters are needed in this case for correction of the dehydration. These 5 liters are approximately 8 per cent of the patients weight of 60 kilograms. This fits in well with our finding from a study of dehydration in humans (9) that the signs of dehydration appear when a patient has lost an amount of body fluid equal to about 6 per cent of his body weight. Before the use of the clinical rule, this 6 per cent figure was used in calculating the amount of saline solution needed for the hydremia of a dehydrated patient (31), and it worked very well. Occasionally, a dehydrated patient is seen who has not been vomiting appreciably nor been losing gastro-intestinal fluids by other channels, but simply has taken nothing by mouth because of nausea and anorexia and has lost body water by the continuous vaporization of water from the skin and lungs and the urine output. The plasma chlorides and the carbon dioxide combining power are found to be close to normal. Such patients need water mainly for a correction of their dehydration, and a calculation of the amount of dextrose solution in water that should be given for this purpose on the basis of 6 per cent of their body weight has worked well. Most dehydrated patients, however, have had appreciable losses of gastro-intestinal fluid and need saline solution for their hydremia. At the University Hospital hypertonic salt solutions, 2 to 5 per cent, are not used for correction of electrolyte and water deficiency because the electrolyte loss has always occurred in hypotonic or isotonic solution, and to return the electrolytes enough water must also be added to the body fluids to make the result isotonic. Also, many dehydrated patients have hemoconcentration (9) as shown by increased hemoglobin, increased hematocrit, and increased blood specific gravity determinations. To add a 5 per cent sodium chloride solution to this already concentrated state is not reasonable.

Returning now to Table IX, after the calculation for Ringer's solution for dehydration, water for vaporization and for urine also has to be considered, hence 3,500 cubic centimeters of 5 per cent dextrose in water is added for this purpose. The total of 8,500 cubic centimeters is a large volume, but experience has shown that such amounts are commonly needed (9) for the first administration to the severely dehydrated patient. Considering this volume, the rate of administration is important. There is no reason for and there may be particular reasons against giving this

volume in the first 24 hours. In old patients and those with cardiac deficiency the need for such caution is quite apparent. The patient will show signs of improvement with the first 2 or 3 liters and it would be much better to administer the 5 liters of Ringer's solution over 2 days, giving 3,500 cubic centimeters of 5 per cent dextrose in distilled water plus 2,500 cubic centimeters of Ringer's solution during the first 24 hours and the same volume of each solution the next 24 hours. This provides time and plenty of easily available water for the correction of internal fluid and electrolyte adjustment. The rate of administration would be approximately 200 cubic centimeters per hour, which is desirable when large volumes of fluid are given. It should be thoroughly understood that once the dehydration is corrected by a calculated fluid need as shown in Table IX, no patient needs a continuation of anything like such large volumes unless he continues to have an abnormal loss of large volumes of electrolyte containing fluids. Once the dehydration is corrected, the subsequent fluid needs are water for vaporization and urine as discussed under water balance in disease, and Ringer's solution for abnormal gastro-intestinal fluid losses on the plan of volume-for-volume replacement.

As just mentioned, the rate of intravenous fluid administration is important, and to meet all considerations 3 procedures are followed at the University Hospital. When moderate volumes of fluid have to be given, 3,500 cubic centimeters or less, the rate is from 300 to 500 cubic centimeters per hour, which is approximately 5 to 8 cubic centimeters per minute. When over 3,500 cubic centimeters are needed, the administration is placed on a 24 hour basis and the rate is reduced to approximately 200 cubic centimeters per hour. When 10 per cent dextrose is given, the rate is set at 150 to 200 cubic centimeters per hour, since Winslow demonstrated in a group of surgical patients that with slow administration close to 95 per cent of the dextrose is retained and the glycosuria is minimum. When the saphenous vein on the leg or a forearm vein away from the antecubital space is used and when the needle and a small portion of the tubing is strapped firmly in place, the patient is allowed a fair degree of motion. It is not pain at the site of the intravenous administration that is unbearable, but inability to change position and move about in bed that makes this therapy so tiresome.

The intravenous drip method has proved to be very satisfactory at the University Hospital. Continuous supervision by a nurse remaining at the bedside while intravenous fluids are being given is not required, and no attempt is made to keep the solutions at a constant temperature while in the intravenous apparatus; they are, however, warm when removed from the storage space in the warming closet.

CONCLUSION

Many problems of fluid and electrolyte balance remain to be solved. We have endeavored to present the fundamental aspects of the therapy as used in our surgical wards. We must emphasize that the best way to maintain this balance is to give food and drink by mouth. If this is not possible and parenteral therapy becomes necessary, a knowledge of the fundamentals enables one to maintain or restore the water and electrolyte balance by supplying with practical accuracy the needs of each individual patient. Parenteral therapy tides over an emergency; the sooner the patient is restored to food and drink by mouth the greater his chance of recovery.

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CONSERVATIVE SURGERY IN THE TREATMENT OF BONE TUMORS

DALLAS B. PHEMISTER, M.D., F.A.C.S., Chicago, Illinois

CONSERVATIVE surgery in the treatment of bone tumors implies the employment of an operative procedure which permits of the conservation of an involved extremity or of the continuity or contour of an involved bone. In the case of benign tumors it finds general application, but in the management of malignancies of bone it has a much more limited field of usefulness.

The type of conservative operation suitable for benign lesions varies a good deal with the different classes of tumors. The commonest benign bone tumor is the cartilaginous exostosis or osteoma which arises in the shafts of bones preformed in cartilage. When, because of size, deformity, or pressure effects, removal seems indicated, its base should be severed with a chisel making sure that every portion capped by or containing cartilage is removed. It is very rare that such a neglected tumor situated in a toe or finger becomes so large that it calls for complete excision of the bone or amputation.

Fibrous osteomas which arise from the bones of the face and skull present a somewhat different problem. In some cases they spring from the surface of the bone producing external circumscribed swellings or at most involve only a relatively small amount of the interior, and may be completely excised in a manner similar to cartilaginous exostoses. In other cases they arise centrally and produce more or less expansion of a segment of the bone, in which event complete excision may mean interruption of continuity of bone and marked deformity. In order to avoid these undesirable results such osteomas occurring in the bones of the face and forehead may be treated by the conservative procedure of incomplete removal. The tumor is exposed through an inconspicuous or the least conspicuous incision, and chiseled away until the normal configuration of the bone is restored. There should be still further removal of as much of the internal portion as is compatible with preservation of continuity and contour. After healing of the soft parts is complete, the remaining portion is treated with roentgenotherapy which usually restrains further growth either to a marked degree or completely. Such tumors usually grow slowly any way. In case there is later enlargement a second operation for restoration of normal contour may be indicated. This treatment is particularly appropriate for fibrous osteomas of the jaws and the peri-orbital frontal regions. It was used with satisfactory results in 5 of the 13 cases of fibrous osteomas of the jaws reported by Phemister and Grimson. The tumors are still under control 4 to 10 years after operation.

Chondromas occur almost entirely in bones preformed in cartilage and, in contrast to cartilaginous exostoses, are nearly always situated within the shafts but produce more or less surface enlargement. The phalanges of the fingers are the usual sites of the lesion. In the great majority of instances they respond to treatment by excision of a window, thorough curettage, cauterization with phenol or other caustic solution, and tight closure of the soft parts. Postoperative irradiation in case of doubt as to complete removal lessens the likelihood of recurrence. Excision of part or all of the bone with replacement by a bone transplant is rarely indicated.

The correct management of benign giant cell tumor is still the subject of debate. In our previously reported experience (11), good results have been obtained in the following way: operative removal of tumor by the application of a tourniquet, excision of a window of cortex, thorough curettage, cauterization with phenol or other caustic solution, filling the cavity with saline and tight suture of soft parts before

From the Department of Surgery, University of Chicago Clinics.

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release of the constrictor, and application of a cast. Operation is followed by 2,000 to 3,000 r's. More radical procedures are rarely employed. In case of very extensive bone destruction, bone transplants may be inserted into the cavity to assist in restoration of the shaft but routine transplantation of bone into the remaining cavity is unnecessary. Complete excision of the involved segment with replacement by a bone transplant, which was formerly used to some extent, is at present still less often indicated. This procedure was used 26 years ago for a tumor of the lower end of the radius and 20 years ago for a tumor of the upper end of the humerus. In each case there is still freedom from recurrence but the functional result from stiffness of the neighboring joint is much poorer than would have followed the more conservative procedure which is now being employed. Excision without replacement by a bone graft is indicated in case the involved bone may be dispensed with as a rib or upper portion of the fibula. Amputation is indicated only in case of complications such as infection following operation with a chronic sinus and failure of healing or malignant degeneration. On the other hand there are many who advocate curettage as Meyerding, Campbell, and Coley and Higinbotham, or curettage and bone grafting as advocated by Camp and Clavelin and Sarroste without subsequent employment of roentgenotherapy because of the conviction either that it is unnecessary or that it actually increases the risk of further growth of the tumor.

Hemangioma of bone, as a rule, need not be operated upon *per se* as it usually is effectively controlled by roentgenotherapy as shown by the report of Bucy and Capp. When the tumor is situated in a region where the involved segment of bone may be excised without impairment of function, it may be treated in that way as was my case of tumor of the clavicle reported by Bucy and Capp.

BONE SARCOMA

The proper treatment of bone sarcomas of the limbs without demonstrable metastases in the great majority of cases is amputation, since before the diagnosis is established the disease has advanced to a point which makes local excision unfeasible. This is because of direct extension of the tumor into muscles or veins or about the main blood vessels of the limb. Such extension is likely to occur earlier in the tumors beginning peripherally than in those beginning centrally in the bone.

That the general surgical profession has shown little tendency to local excision of sarcoma of the extremity bones is shown by the statistics of the Registry of Bone Sarcoma of the American College of Surgeons as of March 1938. However, the Registry records in this respect are somewhat incomplete and indicate a smaller incidence of usage of transplantation than is actually the case. Of the 701 cases of osteogenic sarcoma followed for 5 years or longer, 93 were alive and free from recurrence. In 7 cases the tumor was in a trunk bone and was treated by excision and roentgenotherapy. In the 86 cases in which the tumor was in an extremity bone the treatment was by amputation in 82 cases, by resection and roentgenotherapy in 3 cases, and by resection and bone transplantation in only 1 case. Of 155 cases of Ewing's sarcoma followed for 5 years or more, there were 15 five year survivals 9 of whom were treated in part by amputation and 5 by resection and roentgenotherapy, but in no case was bone grafting recorded.

Eiselsberg and Klapp reported the first cases of successful repair of the defect after resection of bone sarcoma by bone transplantation and there have been numerous reports of isolated cases since. In general, the results have been either inconclusive due to the shortness of the time since operation or discouraging due to recurrences and complications. The first important series of cases, 6 in number, so treated with encouraging results was reported by Lexer. The following cases were free from recurrence with defects restored: 1 of the ulna after 19 years, 1 of the lower end of femur after 7 years, 1 of the humerus after 3 years. One case had a recurrence which necessitated amputation after 3¼ years.

Roscher reported 6 cases of the upper end of the humerus but there was local recurrence with early death in 5 and death from metastases after 13 years in one.

Albee reported 13 cases, 4 of which from the descriptions bore resemblance to benign giant

Fig. 1a

Fig. 1b

Fig. 1. Central osteogenic sarcoma of upper 10 centimeters of the humerus. a, Before operation; b, excised specimen.

Fig. 2. Result in case shown in Figure 1, 3 years and 5 months after excision and bone transplantation.

Fig. 2

cell tumors. There were 6 patients with sarcomas of the lower femur, 5 of whom were well with grafts united 6 months to 2½ years after operation. The other had local infection and recurrence and an amputation was performed. Two patients with sarcoma of the tibia and one patient with sarcoma of the humerus died early of metastases.

My own experience with resection of the involved segment and replacement by bone transplantation consists of 7 cases, 5 of which have been reported previously (11). The results in those cases brought up to date are as follows: One patient with sarcoma of the mandible in whom one-half of the bone was resected and 1½ years later replaced by a transplant was well 7 years later and then was lost track of. One patient with sarcoma of the humerus and 1 of the ulna had local recurrence and metastases and died 2 to 3 years later. One patient with markedly ossifying osteogenic sarcoma of the humerus is now free from metastases 3 years and 5 months after operation (Registry of Bone Sarcoma Case No. 2046).

The patient, a male aged 28 years, had had slight pain and swelling at the right shoulder for 4 months. A roentgenogram (Fig. 1) revealed a diffuse increase in density of the upper 3 inches of humerus and an oval shadow with slight increase in density along its lateral surface. Under the diagnosis of osteogenic sarcoma, the upper 4½ inches of humerus, the deltoid muscle, the muscular attachments to the upper end of humerus, and the capsule of the shoulder joint were excised. The defect was replaced by a broad graft from tibia and the shoulder joint arthrodesed. Gross and microscopic examination confirmed the diagnosis of an ossifying sarcoma. A body and arm cast was worn for 4 months. During the next 8 months the graft was fractured three times by accidents. Despite bone transplantations, one fracture

Fig. 3, left. Osteogenic sarcoma in reconstructed ulna.
Fig. 4. Same case as Figure 3, 5½ years after excision and bone transplantation.

has remained ununited but the arm is useful and the patient continues his work as a dentist. There are no signs of local recurrence or metastases (Fig. 2).

The prospects of a cure are encouraging and if the patient remains free from signs of recurrence much longer, he will be urged to have another bone transplantation for the ununited fracture.

Finally, one case (Registry of Bone Sarcoma No. 288), is free from recurrence 5 years and 7 months after operation.

A female at the age of 22 years had a lesion of the lower end of the radius, diagnosed as a giant cell tumor and treated elsewhere by curettage and radium implantation. Infection and a radium burn developed and the patient lost the lower portion of the radius and much of the surrounding soft tissues. The wound healed in about 3 years with the hand markedly angulated and crippled. Five years later a plastic operation was done by me on the lower end of the ulna and the position of the hand was corrected. Six years later the patient returned with a swelling in the lower end of the ulna and a biopsy revealed a tumor containing scattered giant cells in a round and spindle-celled field with numerous mitotic figures and some tumor ossification. Malignant degeneration of a giant cell tumor was diagnosed. Under a tourniquet the lower end of ulna was excised and replaced by a tibial transplant. The graft was a success (Fig. 4) and there had been no recurrence 5 years and 7 months later.

There was a difference of opinion as to the diagnosis among the members of the Committee of the Registry who examined the excised specimen. Some considered the tumor malignant while others regarded it as still a benign giant cell tumor. I believe it was an osteogenic sarcoma.

Since the previous report, 2 additional cases of sarcoma of the upper end of the tibia have been operated upon by resection and bone transplantation.

Case 1. Female, aged 12 years, first noticed a slight swelling of the upper end of the shaft of right tibia anteromesially 12 months before admission. Five months previously a roentgenogram revealed an oval, flecky shadow of calcium density along the mesial surface of the upper 4 inches of the tibial shaft (Fig. 5). Under the diagnosis of a benign cartilaginous tumor the lesion was then excised locally. There was, however, further growth of the tumor and on admission there was a firm mass over the posterior and lateral sides of the upper 2 inches of the shaft. A roentgenogram revealed a shadow of calcium density most marked along the lateral surface in the upper region of the swelling (Fig. 6). Examination on admission was otherwise negative including roentgenograms of the chest. Under the diagnosis of chondrosarcoma and with tourniquet hemostasis, the upper 5 inches of the tibia were excised; the neck of the fibula was broken accidentally during the maneuver. Under a tourniquet a whole thickness graft of crest and anteromesial cortex of the left tibia was removed and inserted into the defect and the fibula was contacted with external condyle. Figure 7 shows the specimens excised at the 2 operations and microscopic examination revealed a calcifying and ossifying chondrosarcoma of low grade malignancy. Bony union followed, and walking on it with a brace was resumed after 7 months. There was no sign roentgenologically or otherwise of recurrence or metastasis 17 months following operation. Figure 8 shows roentgenographic appearances 1 week and 13 months after operation.

Case 2. A male, aged 15 years, had noted a small, oval, slightly painful swelling of the anteromesial surface of the upper end of the shaft of the right tibia for 2 months before admission. Physical examination confirmed the presence of the swelling but otherwise revealed negative findings. Roentgenograms revealed an oval area of increased density in the mesial aspect of the upper 2 inches of the tibial diaphysis extending slightly beyond the surface (Fig. 9). The lungs were roentgenologically normal. Diagnosis: osteogenic sarcoma. At operation without biopsy under a tourniquet the upper third of the tibia was exposed through an anteromesial incision, leaving an ellipse of overlying skin and subcutaneous fat attached to it. Muscles were reflected posteromesially and laterally and the upper tibiofibular joint

Fig. 5

Fig. 6

Fig. 8a

Fig. 8b

Fig. 8c

Fig. 5. Case 1. Chondrosarcoma of upper end of tibia.
Fig. 6. Case 1. Showing further growth of tumor 5 months after regional excision.

Fig. 8. Case 1. a, Shows transplant 1 week after operation; b and c, roentgenographic appearances 13 months after operation.

was sectioned. The bone was divided with a wire saw 4 inches below the knee and the upper fragment was lifted forward. The remaining muscular attachments were then divided wide of the bone and the knee joint capsule and ligaments were cut which permitted removal of the fragment without exposure of the tumor. The tourniquet was removed and the bleeding points were ligated. The anterior tibial artery which had been divided was ligated. A sterile tourniquet was then applied to the left thigh and a 9 inch graft was removed from the crest and anteromesial surface of the tibia. It was cut in 2, 1 piece being 5 and the other 4 inches long. The ends of the longer graft were inserted into the medullary canal of the distal fragment and into a groove cut in the mesial condyle of the femur. The shorter graft was inserted lateral to it and sponge grafts were inserted between the denuded head of fibula and denuded lateral condyle. Soft parts were closed tightly although there was a dead space about the grafts which had to fill with blood. A cast was applied to limb and body. Figure 10 shows the roentgenogram 1 week later. An area of necrosis 1 by 2 inches in extent developed in the lateral flap. This gradually separated and the anterior portion of the underlying grafts became exposed. A low grade infection was finally established in the field and 4 months after operation it was questionable if any portion of the 2 large grafts had survived.

Examination of the specimen showed the densely ossified tumor to bulge only slightly beyond the mesial surface. A microscopic section of the entire specimen (Fig. 11) reveals tumor bone throughout the extent of the sarcoma, and in the region of cortical penetration tumor invasion of 2 small surface veins.

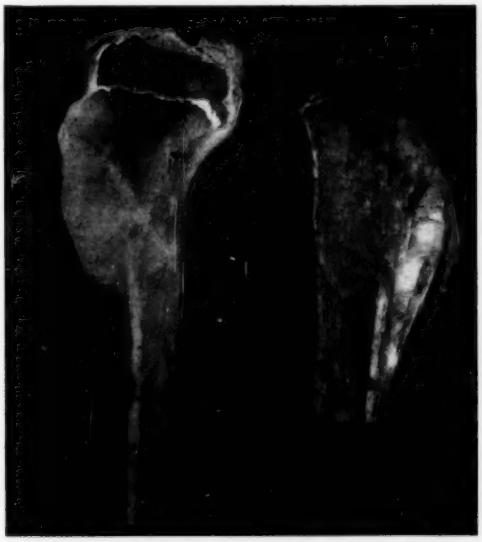

Fig. 7. Case 1. Specimens excised: a, left, at first operation; b, at second operation.

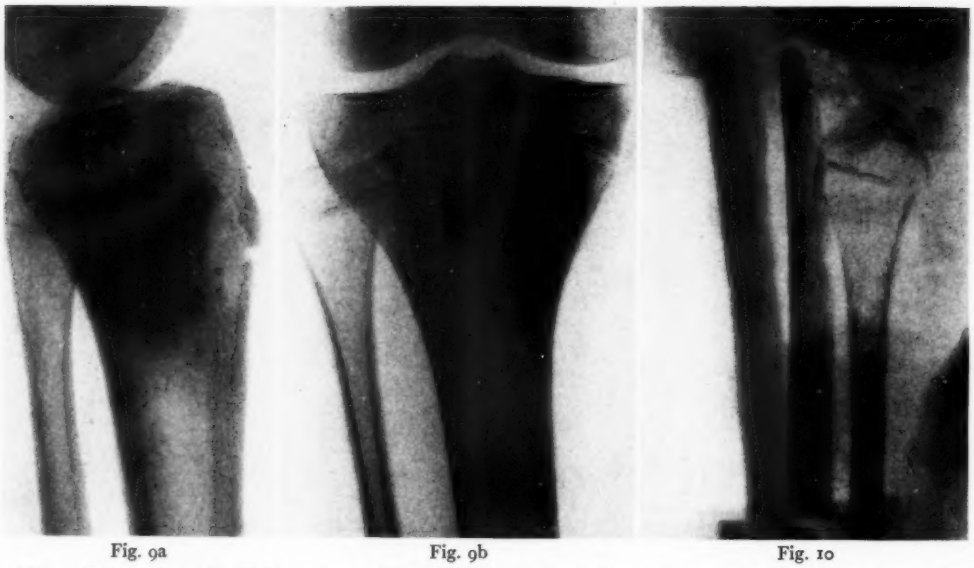

Fig. 9a Fig. 9b Fig. 10

Fig. 9. Case 2. Central ossifying sarcoma of upper end of tibia.

Fig. 10. Case 2. Bone grafts in position 1 week after operation.

Despite the flap necrosis and loss of bone graft it should be possible later on to restore the continuity of the tibia with ankylosis at the knee by shifting the divided fibula into the defect. The case is reported at this early date to illustrate the dangers that may be encountered in a case which at the beginning because of its confinement to the bone appeared most suitable for this type of operation.

Fig. 11. Case 2. Microscopic section showing distribution of ossified tumor within the cancellous region and beneath the slightly elevated periosteum.

Local excision of the sarcoma without interruption of continuity of the segment of bone is a procedure to be avoided except under very pressing circumstances as inability to obtain consent or certainty of marked loss of function after a more extensive operation. However, it is worth knowing that if such a procedure is combined with roentgenotherapy, there may be repair of bone and freedom from recurrence of the tumor for worth while periods of time as illustrated by the following cases:

CASE 3. Male, aged 23 years. The patient complained of gradually increasing pain in the right shoulder for 7 months with only slight impairment of function. Physical examination was negative aside from slight limitation of motion in the right shoulder. Roentgenograms of the chest showed normal appearing lung fields. A roentgenogram of the right shoulder revealed a large area of destruction in the mesial portion of the metaphysis and adjacent head of the humerus with rather hazy outlines (Fig.

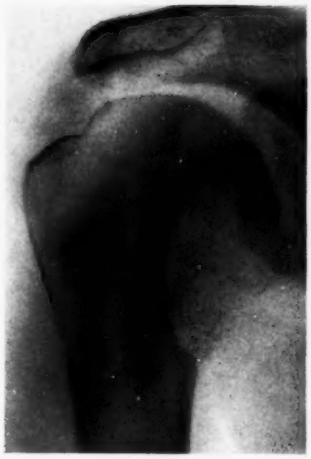

Fig. 12

Fig. 13

Fig. 14

Fig. 12. Case 3. Chondrosarcoma of humerus.
Fig. 13. Case 3. Photomicrograph showing hyaline and calcified chondrosarcoma.

Fig. 14. Case 3. Roentgenogram showing condition 5 years and 1 month after local excision and roentgenotherapy.

12). Sarcoma, benign giant cell tumor, and cyst were considered. At operation the tumor was cut into and a soft, bluish-gray tissue removed. Frozen section revealed a chondrosarcoma, which diagnosis was later confirmed by fixed tissue sections (Fig. 13). The lesion was then thoroughly curetted and chiseled away and the soft parts closed tightly. Within 60 days following operation the patient received 7,500 r's. The pain disappeared from the shoulder and 5 years and 5 months afterward he was free from clinical and roentgenographic evidences of local recurrence or metastases. Figure 14 shows the roentgenographic evidence of healing of the bone defect. Moderate muscle atrophy and limitation of motion of the right shoulder are present.

CASE 4. Female, aged 23 years. For 2 years the patient had had pains in the region of the right hip which had gradually progressed, causing a limp and interference with function. Six months before admission a tumor of the ilium was diagnosed elsewhere and 5,250 r's were given, 2,550 anteriorly and 2,700 posteriorly to the region. Some improvement in local symptoms followed the treatment but the pain had been worse for the past 2 months following a fall.

Examination was essentially negative aside from a decided limp in the right lower limb, limitation of motion of the right hip, and a slight swelling deep seated and low over the back of the right ilium. A roentgenogram (Fig. 15) revealed extensive destruction of bone of the top of the acetabulum and of the adjacent ilium for a distance of 2 to 3 inches. At operation (Dr. Harkins) the posterior surface of the lower ilium was exposed by splitting the lower part of the gluteus maximus muscle and reflecting the underlying rotator muscles. The cortex was missing and a soft tumor with a fibrous covering bulged from the surface of the ilium. It was removed by chiseling, dissection, and thorough curettage. The tumor was grayish-brown in color and there was relatively little bleeding. The acetabular roof was completely eroded for an area 1 centimeter in diameter. Microscopic examination of the tissue (Fig. 16) showed extensive necrosis scattered throughout a round and spindle-celled tumor undoubtedly the effect of the x-ray. But in the viable regions the tissue was composed of spindle cells presenting the appearance of a fibrosarcoma. There was primary wound healing. Fourteen hundred r's were then given. The patient walked without crutches 2 months following operation, the limp rapidly disappeared, and she is now free of all symptoms and signs of tumor 3 years after operation (Fig. 17).

While it is difficult to evaluate the rôles of roentgenotherapy and operation in the healing, it seems rational to assume that the removal of the tissue, which was partly of viable spindle-cell structure, was a factor of some importance in controlling the process.

CASE 5. Female, aged 42 years. The patient had had pain in the region of the left hip for 8 months which gradually increased and was aggravated by exertion, causing her to limp. There were no general symptoms nor weight loss. Physical examination was

Fig. 15

Fig. 17

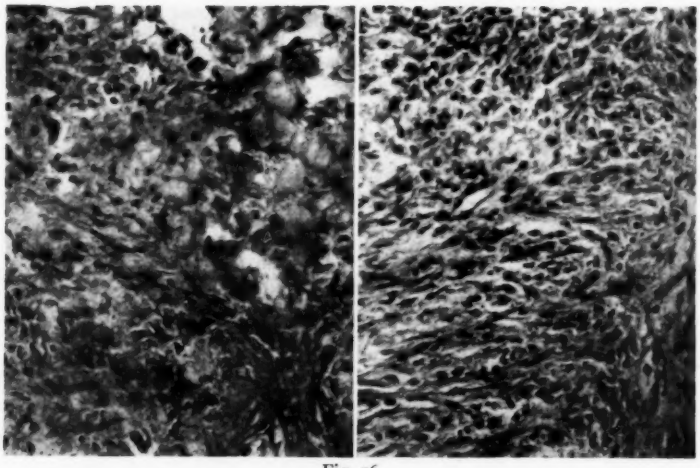

Fig. 16

Fig. 15. Case 4. Roentgenogram of a non-ossifying sarcoma of ilium.
Fig. 16. Case 4. Photomicrographs: a, left, partly degenerated and calcified area (effect of roentgenotherapy); b, viable area.
Fig. 17. Case 4. Roentgenogram showing condition 2 years and 11 months after operation.

essentially negative aside from the left hip region. There was slight tenderness on palpation just above the greater trochanter but no mass was felt. A roentgenogram (Fig. 18) revealed an oval area of reduced density with more or less worm eaten outlines in the left ilium just above the acetabulum. Roentgenograms of the chest showed no signs of metastases.

A diagnosis of sarcoma of the ilium was made. At operation the gluteal muscles were reflected from the side of the ilium exposing a tumor which was covered in some regions by a thin layer of bone and in others only by thickened periosteum. The covering was cut away and a moderately vascular, grayish, soft tumor was dissected and thoroughly curetted. Eighteen radon seeds were then implanted about the walls and the wound was tightly closed. The pathological report was that of the Ewing type of round cell sarcoma. The wound healed by primary union. Roentgenotherapy was begun 2 weeks later and during the following 6 months she received 4,400 r's.

Fig. 18

Fig. 19a

Fig. 19b

Fig. 18. Case 5. Ewing sarcoma of ilium.
Fig. 19. Case 5. a, Two weeks after the excision and radon seed implantation; b, the result 1 year later after roentgenotherapy.

Fig. 20. Case 5. Sarcoma of clavicle with pathological fracture.

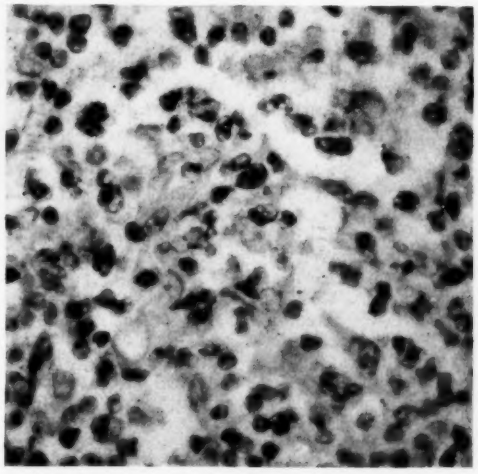

Fig. 21. Case 5. Photomicrograph of biopsy specimen.

Fig. 22. Case 5. Four and one-half months later. Repair following roentgenotherapy.

Fig. 23. Case 5. Section of excised clavicle showing fibrous union of fracture and disappearance of soft tumor.

Pain gradually disappeared and function returned to normal during the period. The roentgenograms (Fig. 19) taken 2 weeks and again 1 year after operation show the defect and the repair which followed. Chest symptoms developed about 1 year after operation and pulmonary metastases, demonstrated roentgenologically, resulted in a fatal termination 7 months later without recurrence of symptoms or signs at the seat of the primary tumor.

A bone sarcoma of the radiosensitive type which is so extensive that an attempt at local removal seems inadvisable may first be treated by roentgenotherapy and then excised in case it becomes sufficiently reduced in size. Excision may be resorted to even when the sarcoma appears to have been eradicated by roentgenotherapy since in such cases growth may again set in after long periods have elapsed. Thus a sarcoma of the upper third of the femur repaired strikingly under roentgenotherapy but recurred 4 years later. Bone transplantation for repair of the defect after excision may or may not be indicated according to the region involved. In the following successful case involving the outer one-third of the clavicle the functional result was satisfactory without it.

CASE 6. A male, aged 33 years, sustained a pathological fracture of the outer third of the clavicle. Examination revealed a soft tumor of the outer third of the clavicle with ecchymosis. A roentgenogram (Fig. 20) showed irregular bone destruction and a fracture through the region. A biopsy (Fig. 21) disclosed a round cell sarcoma (recently pronounced a reticulum cell sarcoma by some committee members of the Registry of Bone Sarcoma). Because of the size of the tumor and of the hematoma in and about it excision did not seem possible. The only feasible operation would have been intrathoracoscapular amputation. Intensive roentgenotherapy was then administered and the mass disappeared. Four and one-half months after the biopsy the clavicle was excised including the tissues adjacent to the region of the tumor. A study of the specimen showed the absence of a tumor and fibrous union of the fracture (Fig. 22). Microscopic sections showed no definitely recognizable tumor cells in either the bone or the surrounding soft parts. There was primary wound healing and in the course of a few months the function of the extremity returned to normal. The patient has remained well and 14 years later there is no sign of local recurrence of the tumor or of metastases.

CONCLUSIONS

These experiences warrant the conclusion that in carefully selected cases resection of bone sarcoma and repair of the defect with a bone graft is a justifiable procedure which may save an extremity and carries only slightly more risk to life than does amputation. Also in cases in which for any reason amputation or resection of the involved segment cannot be carried out a combination of local excision and roentgenotherapy offers a somewhat better prognosis than roentgenotherapy alone.

By the employment of these procedures a limited percentage of extremities could be saved that are now being sacrificed by amputation.

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DECOMPRESSION IN THE TREATMENT OF INTESTINAL OBSTRUCTION

CHARLES G. JOHNSTON, M.D., M.S., F.A.C.S., Detroit, Michigan

DECOMPRESSION of the intestine is the oldest and most obvious form of treatment for intestinal obstruction. I speak of decompression in its broadest sense without respect to the method by which it is accomplished. The oldest method of decompression of the obstructed bowel is that of blind puncture of distended loops of the bowel by use of a needle or trocar. This method was occasionally successful in relieving distention, but it rarely relieved the patient of the obstruction. Carried out blindly, it offered little to the patient except the dangers of peritonitis and the method never became popular.

A more controlled method of decompression of the distended bowel, enterostomy, has been practiced with more success for over a hundred years. In cases of simple acute obstruction enterostomy was sufficient to relieve the obstruction, but in the majority of cases left much to be desired, since it did not attack the cause of the obstruction; and when used as a preliminary operation, enterostomy did not always restore the patient to better health preparatory to an attack on the obstruction itself. The appraisal of the use of enterostomy in the treatment of intestinal obstruction given by Treves, in 1884, seems worthy of quotation:

"I cannot avoid the conclusion that a primary enterotomy is not to be advised. The operation is at the best but a palliative measure; it is not founded upon sound surgical principles; it is a procedure that is carried out more or less independently of diagnosis; it is an operation done in the dark, and it leaves the cause of the disorder untouched. It is true that it does not show so high a mortality as does laparotomy, but the disadvantages of the procedure are many. In the first place, as already stated, it leaves the real malady itself untouched. To this statement there are a few exceptions. There are some forms of obstruction that are in great measure produced and maintained by distention of the bowel; among such are certain forms of volvulus (which are rare), some cases of occlusion by kinking, by adhesions, and by changes in the visceral peritoneum or mesentery. Such cases may be cured by enterotomy, and a closure of the artificial anus may follow the operation. Some cases also of faecal accumulation and of obstruction by a foreign substance may be so far relieved by enterotomy that the artificial anus may close in time, or be closed by some plastic measure. But how stands the matter in other cases? The obstruction remains. If it be an example of acute strangulation, or of volvulus, or of intussusception, then the gut may become in time gangrenous, and the patient die practically of the direct effects of an unrelieved, or imperfectly relieved, obstruction of the bowel. If the obstruction be due to cancer, the cancer is left untouched, and the operation merely gives some temporary relief. Suppose, however, that after the enterotomy no further changes of a destructive or malignant character take place about the seat of obstruction; what is the condition of the patient? There is a permanent faecal fistula in the groin. This leads into the small intestine, and may be the cause of wasting, and, if higher up in the bowel than usual, of death from marasmus. There may be, moreover, a considerable portion of intestine between the artificial anus and the obstruction, and the accumulation of faecal matter in this part of the bowel may lead to the greatest distress. The ileum has actually been opened to relieve a case, not diagnosed at the time, of simple stricture in the upper part of the rectum, and in other examples of enterotomy the seat of the obstruction has been in the descending colon and the sigmoid flexure."

Despite these deprecating remarks, enterostomy has advantages in selected cases of intestinal obstruction. The procedure is simple and may be applied to those patients who could not stand the exploration necessary to find and correct the cause of the obstruction. It permits decompression of the distended bowel and allows the patient to eat and absorb nourishment at least down to the point of the opening in the bowel. Careful attention to the wound and to an adequate supply of fluids parenterally may be expected to minimize the dangers of wasting.

From Department of Surgery, Wayne University College of Medicine and the Detroit Receiving Hospital.

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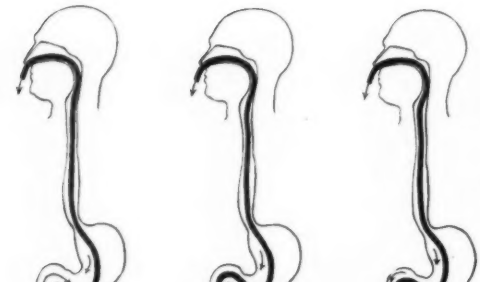

Fig. 1. Illustration of differences in direction of flow in intubation at various levels and by enterostomy. a, Gastric drainage; b, duodenal drainage; c, small intestinal drainage.

While these methods owe their effectiveness to decompression of the bowel, the modern connotation of the term decompression relates to the use of tubes introduced into the intestinal tract through natural orifices.

This method of accomplishing relief of distention likewise is not new. Westermann, in 1910, reported the use of continuous gastric drainage in cases of ileus associated with peritonitis and stated that the method was first used by Tarnier in 1888. However, as an adjunct in the treatment of intestinal obstruction it has only recently been widely used. Ward, in 1925, advocated the use of gastric intubation with suction in the treatment of intestinal obstruction, and Wangensteen and his associates have greatly extended the use of the method by their many studies and have emphasized the need for passing the tube into the duodenum. Shortly after the report on this subject by Wangensteen and Paine we became interested in the use of duodenal siphonage, and after some experience recognized the method as a decided advance in the treatment of intestinal obstruction. There were, however, certain cases in which no marked relief or at best only temporary relief was attained. It was my good fortune to be acquainted with the work of Dr. William Osler Abbott and Dr. T. Grier Miller at the University of Pennsylvania when they were developing their tube for intubation of the small intestine. The Miller-Abbott tube offered the possibility of extending the efficacy of suction drainage, by affording drainage at bottom rather than at top of distended column of fluid and gas. With Dr. Abbott the method was tried and found to be practical (1, 8).

Actually, the underlying principle of the various methods of decompression by means of intubation is the same; differences lie only in the level from which the material is aspirated. With the intestinal tube at the level of the obstruction, adequate aspiration is similar to an enterostomy performed just above the level of the obstruction (Fig. 1), and has this additional advantage—the level from which material is aspirated may be varied at will.

The method for accomplishing intestinal intubation has been described in other publications (1, 8, 9, 12, 13). It consists of the use of a tube approximately 10 feet in length at the lower end of which an inflatable balloon is attached. With the tube in the duodenum the balloon is inflated and peristalsis propels the tube downward until stopped by obstruction to its passage. We prefer the use of a large tube for aspiration with a smaller tube for inflation of the balloon rather than the original double lumen tube; they have been found more efficacious in supplying drainage and they are much cheaper (Fig. 2).

Obviously, with decompression possible when the tip of the tube is in the stomach or duodenum, many of our patients have not required that the tube be passed further. However, with the advantages offered by intestinal intubation in the determination of the type, extent, and level of the obstructing lesion, we have in many cases allowed the tube to pass further even when not necessary for relief of distention. One other advantage afforded is that with the tube passed well down in the small intestine the patient may be fed a diet low in fiber content, and absorption of food, fluid, and salt occurs. In obstruction low in small intestine it is frequently possible to maintain nutrition, fluid, and salt balance without resort to parenteral fluids.

The disadvantages as well as the advantages of intestinal intubation in the treatment of intestinal obstruction are well kept in mind. Of the disadvantages the most obvious is the possibility of failure to recognize interference with the mesenteric blood supply. That the recognition of strangulation is possible on the basis of the history, physical examination, and reaction of the patient is evidenced by the fact that of the last 22 such cases, accurate diagnosis was made in all but one and in this case the history, onset, and development of symptoms before entering the hospital were inaccurately given. Even were it not possible to recognize strangulated obstruction, on the basis of the relatively low incidence of this condition, it would not cause a serious increase in the mortality rate.

The difficulty of introducing the tube into the duodenum in certain cases is a handicap in this method. During the past 3 years we have had 6 patients in whom we were unable to pass the tube into the small intestine. During this time we have successfully passed the tube into the small intestine approximately 500 times. There is no doubt that intubation of the small intestine is hard work and requires constant care if it is to be effective.

The tube occasionally causes irritation to the nose and throat and is uncomfortable, but this can usually be controlled by lubrication and by instillation of a solution of 1 per cent metycaine or nupercaine into the nostril. We had one patient who developed otitis media during treatment, and another in which there was a rupture of esophageal varices presumably from trauma by the tube.

The advantages might be listed as follows: (1) It offers a means for relieving the patient's distention without operation, thus relieving him of his symptoms. (2) This procedure makes it possible to delay surgery safely until the patient is in better general condition with a normal fluid and chemical balance. (3) Operation then becomes a procedure of election rather than of emergency. The technical difficulties attendant upon operating amid distended loops is removed. (4) It is frequently possible to localize the obstruction accurately before operation by means of small amounts of barium given through the tube

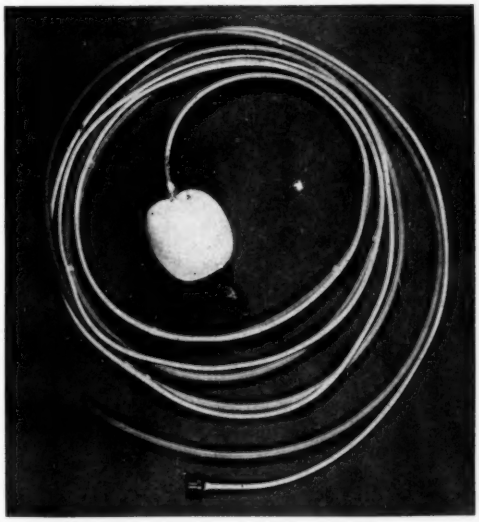

Fig. 2. Intestinal tube which we have found most practical.

(10). The barium can be washed out at will following roentgenographic studies, since the tube tip lies at the point where the barium puddles. (5) Once the tube passes well into the small bowel much of the absorptive area of the intestine lies above its tip. It is then possible to maintain the patient's nutrition by oral feeding of a high caloric and low fiber diet. This is not possible when gastric or duodenal aspiration is in progress. (6) In adynamic ileus there seems to be always enough muscular power left in the intestinal wall to pass the tube down once the overdistention is relieved. No other method we have tried has approached the uniformly successful results we have had in treating adynamic ileus by intubation.

In addition to intestinal obstruction we have found the use of intestinal intubation of assistance in other conditions. Incisional hernias so large as to appear inoperable may be successfully repaired after the passage of the tube well down in the small bowel. After intubation the volume of the intra-abdominal content is smaller. This permits not only of adequate reposition of intestine without undue tension from pressure within the abdomen, but assures the ability to control postopera-

TABLE I.—MORTALITY FROM SIMPLE INTESTINAL OBSTRUCTION

	No.	Per cent
Lived	51	80.9
Died of obstruction	6	9.5
Died of other causes, distention present	3	4.8
Died of other causes, no distention	3	4.8
Total mortality—all causes		19.1

This represents 63 patients treated by intubation, but does not include cases of strangulated obstruction, adynamic ileus, or patients operated upon without intubation.

tive distention. Intubation to produce what is in effect a low ileostomy, preceding operations on the large bowel, has been reported to me by Dr. I. S. Ravdin. We have used the method in controlling loss of fluid with the associated digestion of superficial tissues due to leak from an enterostomy opening. We have had but one of these cases, and this patient's difficulty might well have been obviated by use of the tube primarily instead of the performance of the enterostomy.

In our experience the use of intestinal intubation has had a decided effect on the reduction of mortality from intestinal obstruction. During the past 3 years we have had 64 cases of simple intestinal obstruction with a mortality of 9.5 per cent. In the group of cases where the obstruction was not the chief cause of death the mortality was 9.5 per cent. Including all cases, whether or not the obstruction played any rôle in the demise, the mortality was 19.1 per cent (Tables I and II). These figures do not include cases of intestinal obstruction unsuitable for treatment by intubation such as strangulated obstruction and uncomplicated cases of intestinal obstruction which were operated upon immediately because of lack of reaction or excessive distention, nor do they include cases of adynamic ileus which were treated by intubation. Of the latter group a survey has been made which does not materially change the mortality in the entire series treated by decompression, since there were 72 of these patients of which 17 died. The mortality in this group was 23.6 per cent, the deaths being due, with but 3 exceptions, to intraperitoneal infections.

The philosophy behind the use of decompression is based on sound principles. It is worthy of note that there have been many concepts developed with regard to the causative factors for the trend of events in fatal cases of intestinal obstruction and from these concepts have come worthwhile contributions to therapy. It is unfortunate that the rôle of distention in initiating other more serious considerations, should have received so little attention. In addition to the work of Wangensteen in stressing the importance of decompression, the experimental data of Herrin and Meek, Taylor and associates, and Burget and associates have done much to consolidate the concept that with the control of distention, other disastrous phases of intestinal obstruction need not follow.

These workers proved that it is possible to produce the symptoms of intestinal obstruction by distending the intestine even when no

TABLE II.—PATIENTS WHO DIED AS A RESULT OF OBSTRUCTION

Patient and age	Cause of death	Decompression	Remarks
L. V., 81	Richter's hernia, perforation of ileum, peritonitis	Unsuccessful	Patient had diaphragmatic hernia. Unrecognized Richter's hernia. Tube never left stomach.
M. T., 69	Perforation of ileum, peritonitis	1. Successful 2. Unsuccessful	Patient emaciated, obstruction at terminal ileum completely decompressed. Patient ready after 26 days intubation, but operation deferred to allow gain in strength. After 4 days she re-obstructed and intestine perforated before tube could be passed. Fine adhesive band found across terminal ileum with pin point perforation.
N. G., 75	Intestinal obstruction	Successful (late)	Refused all treatment. Home on release. Returned 5 days later. Wanted to die and refused intubation. Intubated successfully when moribund.
H. B., 20	Intestinal obstruction	Successful	Refused intubation. Adhesive band released at operation. In good shape for 8 days. Crampy pains recurred and relieved by intubation. Sudden return of abdominal pain 12 hrs. before death. X-ray showed complete decompression.
H. G., 56	Intestinal obstruction, uremia	Successful	Chronic intestinal obstruction nitrogen retention, as result of long standing distention, decompressed, chlorides normal but azotemia uncontrolled.
M. B., 45	Perforation of intestine and peritonitis, thyroid crisis	Unsuccessful	Previously suffering from hyperthyroidism, a thyroid crisis precipitated by obstruction. Tube in duodenum, patient pulled it out in delirium and could not be re-introduced. Autopsy revealed static ulcers of intestine due to protracted distention with perforation and peritonitis.

TABLE III.—PATIENTS WHO DIED FROM CAUSES OTHER THAN OBSTRUCTION—DISTENTION A PART IN OUTCOME

Patient and age	Cause of death	Decompression	Remarks
J. O., 52	Nephritis, diabetes mellitis, uremia	Partially successful	Patient had old fistula following enterostomy. Tube thought not to offer advantage, inserted but removed by irrational patient. Blood sugar, 390; urea, 115, CO_2, 33. Chlorides always within normal limits.
A. O., 77	Pyelonephritis, retroperitoneal abscess	Successful	Ten days distention and obstipation. Gastric suction 3 days before seen by us. Patient died of infection, but long continued distention probably played a part in her death.
R. J., 26	Pyelonephritis, uremia	Successful	Patient's obstruction overcome at this and two previous admissions. Previous admission for pyelonephritis. Abdomen flat one week before death. Chlorides within normal limits, Blood urea, 118.

TABLE IV.—PATIENTS WHO DIED FROM CAUSES OTHER THAN OBSTRUCTION—DISTENTION NO PART IN OUTCOME

Patient and age	Cause of death	Decompression	Remarks
W. P., 13	Tuberculous peritonitis	Successful	Tuberculous peritonitis.
V. J., 37	Subhepatic abscess	Successful	Pelvic abscess, with wide-spread peritonitis.
A. G., 67	Myocardial failure and pulmonary edema	Successful	Gall-stone obstruction, uremic and disoriented on admission. Prepared for operation for 3 weeks, gall-stone removed. Patient died of myocardial failure 9 days later. Autopsy revealed no cause for death in abdomen.

obstruction is present, and that even in the case of a closed loop obstruction, deleterious symptoms could be prevented by decompression of the loop.

It is worthwhile to point out that decompression of the bowel in simple intestinal obstruction is but one phase in the treatment of this condition. The necessity of supplying fluid and salt as emphasized by Andries and McLean, Hartwell and Hoguet, and later by Haden and Orr, McIver, Coller and others is important, no matter what other therapeutic measures are carried out. In obstruction due to a definite organic lesion, operation is still an imperative necessity, but with advances in the control of the distention by intestinal intubation and better localization of the lesion the operation is made easier for the surgeon and less formidable for the patient.

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THE MANAGEMENT OF CHRONIC PELVIC INFECTIONS

GEORGE H. GARDNER, M.D., F.A.C.S., Chicago, Illinois

ALTHOUGH pelvic infections still occupy an extremely important position among gynecological problems, tubal disease is a less frequent indication for surgery nowadays. The chief factors responsible for this decrease are less gonorrhea in women and an almost universal adoption of non-operative management for acute salpingitis. With the decreased incidence of gonorrheal salpingitis there has been an increase in pelvic endometriosis; to us, this appears to be further confirmation of Sampson's "retrograde menstruation and implantation of endometrium" theory. In other words, the more tubes that are patent, the greater the likelihood for endometriosis to develop.

We usually think of acute inflammation of the internal genitalia as the result of an ascending gonorrheal infection, as an aftermath of an infected abortion, or as a feature of puerperal sepsis. However, it is my impression that a considerable number of the acute pelvic problems encountered today are not gonorrheal, postabortive, nor puerperal; they are not tuberculous and they do not follow acute appendicitis. These upper genital infections are becoming more and more difficult to decipher. No doubt some result from a spread of an inflammation in contiguous structures; a few are pelvic localizations from a distant focus of infection. Some result from an endocervicitis complicated by a cervical stricture; others are an aftermath either of too ambitious endocervical cauterization or of intra-uterine radium therapy, especially when the uterus is retroflexed. A few may be dependent on the present vogue in feminine hygiene, namely, the wearing of vaginal tampons rather than the conventional vulval pads. Some believe that a trichomonas infestation is responsible for an occasional acute inflammation in the upper genital zone.

From the Department of Obstetrics and Gynecology, Northwestern University Medical School, and the Gynecologic Service of Passavant Memorial Hospital.

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Acute salpingitis should not be a surgical problem because the disease is usually self-limited. The period of morbidity is shorter with conservative management; furthermore, acutely inflamed structures are more likely to rehabilitate themselves if they are not mutilated by operative trauma.

Women with acute tubal disease may require surgical interference when physical signs and clinical symptoms suggest an associated acute appendicitis, which is extremely rare, and also if there is a localization of pus in the cul-de-sac which can be drained readily via a posterior colpotomy. I am impressed, however, that there is a tendency to institute cul-de-sac drainage too frequently nowadays. Attempts to drain inaccessible adnexal masses by this route should be discouraged. Posterior colpotomy with drainage should be reserved for a bulging pelvic abscess, when there is persistent fever, a high leucocyte count, and clinical observation has demonstrated that the patient's general condition is not improving. If one is conservative, he will find that many pelvic masses resolve promptly and spontaneously without resorting to cul-de-sac drainage.

All of us, occasionally, have been chagrined to operate on an acute tubal infection, when we suspected either an acute appendix, a tubal pregnancy, or an ovarian cyst with a twisted pedicle. These questions arise: Shall the tubes be removed or is it advisable to close the abdomen immediately? Is an appendectomy permissible? Is drainage necessary? Each case must be managed on its own merits. If one is dealing with the first attack of an acute salpingitis, he should be more conservative than in a patient who has had previous tubal infections. If the tubal involvement is a simple catarrhal inflammation and the fimbriæ are free, one should not remove the tubes. If the tubes are thickened, filled with pus, and the fimbriæ are sealed, they may be removed; one can scarcely imagine that sealed tubes will undergo spontaneous resolution and

again become patent. The appendix may be removed, routinely. Few, if any of these cases, require drainage.

Gynecologists are inclined to use drains too frequently. They are necessary when the integrity of the rectum, sigmoid, ureter, or bladder is in question. They are also indicated if one drains an abscess; but the routine use of drains after a total hysterectomy probably increases postoperative morbidity. In pelvic surgery drains through the posterior vaginal fornix are preferable to drains through the abdominal wall. Gravity favors the escape of fluids through a vaginal drainage tract whereas the abdominal wall is often weakened by the use of a drain. The incidence of ventral hernias, after gynecological operations, seems to vary directly with the presence of infection in the abdominal wall and with the use of drainage tubes.

We are delighted with recent additions to the older methods of conservative treatment for acute tubal disease. Sulfanilamide has found one of its chief fields of usefulness in the Frauenklinik, i.e., in the treatment of acute gonorrhea and in the management of postabortive and puerperal infections. We are also enthusiastic about pelvic heat therapy as an aid in hastening resolution of subacutely inflamed pelvic structures; my personal experience is limited to the Elliott apparatus and to diathermy.

Relatively few women with acute gonorrheal salpingitis, postabortive infections, and puerperal sepsis ultimately require surgery for the correction of the residues of the acute inflammation. This does not imply that most of the acutely inflamed structures eventually undergo complete resolution and that the pelvic organs return to a normal state, but it does mean that only a few of the end-result lesions are responsible for symptoms.

Granting that acute pelvic infections should be treated conservatively by expectant measures, and recognizing that approximately 20 per cent eventually require surgical interference, how is one to determine when the process has reached a stage of chronicity from which no further improvement can be expected by palliative measures? The time element is an important factor. One should wait at least a year, or preferably a year and a half, after an acute attack of gonorrheal salpingitis has subsided before operating, the only exception being the individual who repeatedly is reinfected. Under such circumstances the operation should be performed soon after an acute attack has subsided, i.e., before she has an opportunity to become infected again. After a cellulitis type of infection one should postpone operation indefinitely. The resolution of such a process is slower and the dangers of operating are greater, because streptococci tend to linger for months, even years, in the pelvic tissues. The presence of fever is a contra-indication to surgical interference, unless one is operating to drain an abscess or to remove it. By the same token a high leucocyte count, with a relative preponderance of polymorphonuclear neutrophiles, is a contra-indication to surgery. We have not been impressed by the sedimentation rate as a helpful measure in distinguishing between active and chronic infections, although a rapid sedimentation rate is more likely to occur with an active infection. Exquisite pelvic tenderness, induration of tissues, and the presence of cellulitis usually denote a relatively active infection.

Most women, with pelvic residues which require surgery, present the following complaints: pelvic pain, uterine bleeding, or sterility. Rarely are pelvic residues a focus of infection. We have seen chronic ovarian abscesses, Skene's duct abscesses, and pyometra due to cervical obstructions that were foci of infection; however, these sites exhaust the practical possibilities in the female genital tract for such foci.

Occasionally, operation becomes necessary because an ovarian abscess or a tubo-ovarian abscess fails to resolve after months of careful palliative management. Under such conditions removal of the abscess is the preferred procedure. Removal is sometimes impossible, usually it is a dangerous undertaking; frequently loops of small bowel, the rectum, a ureter, or the bladder are adherent to it, and these viscera may be injured as one attempts to mobilize the abscess. However, if the sigmoid or rectum is injured at such an operation it tends to close spontaneously; the same

pertains to a vesical fistula produced in this manner. It follows, therefore, that drains should be used, almost routinely, after the removal of an ovarian or tubo-ovarian abscess.

Rarely are we confronted by a chronic cul-de-sac sinus or a persistent lower abdominal sinus. It has been our experience that such sinuses become chronic either because there is a foreign body in the sinus tract, because the primary infection was tuberculosis, or because there is an ovarian abscess which drains continuously and thus prevents spontaneous healing. Under such conditions the entire sinus tract should be removed, including the focus responsible for its persistence.

Genital tuberculosis is rare. It is an extremely difficult pre-operative diagnosis and we have not been impressed that these women are usually amenorrheic; most of them consult us because of uterine bleeding. We also recognize the difficulties in diagnosing tuberculous salpingitis at the operating table. However, the following gross features merit comment: Tuberculous adhesions are dense and unyielding. The tubes, although inflamed and thickened, tend to be pale rather than reddened; in 50 per cent the fimbriæ are said to be free. On palpation, the tubes may be nodular or beaded and occasionally one may see or feel tubercles on the serosal surfaces. Genital tuberculosis is a secondary lesion and, as a rule, results from the scavenger action of the fallopian tubes in picking up caseous fragments or tubercle bacilli that have been spilled into the abdominal cavity from intestinal or mesenteric foci. Tuberculosis extends downward through the genital tract along mucosal surfaces. Consequently, the incidence of tuberculosis in a given genital site varies inversely with the distance of the organ under consideration from the fimbriated ends of the tubes. In other words, tuberculosis of the tubes is most common; tuberculosis of the ovaries and endometrium is next in frequency while involvement of the cervix, vagina, and vulva is extremely rare. Radical operative procedures are indicated; usually, it is unwise to preserve an ovary in the face of a tuberculous infection. Afterward these women should be managed by an internist; a sojourn in a sanitarium is often beneficial.

It is customary, when elective gynecological laparotomies are performed, to explore the upper abdomen before investigating the pelvis. We have been particularly interested in a syndrome, first described in 1930 by Dr. Arthur H. Curtis. It consists of string-like adhesions between the capsule of the liver and the diaphragm, although adhesions are not present in the general abdominal cavity; almost invariably, however, there are pelvic residues of a previous gonorrheal infection. Curtis found, in reviewing histories of patients with these "violin-string" adhesions over the liver, that some had experienced right-sided "pleurisy" pains during an attack of acute salpingitis. He also has had the opportunity to observe women with right-sided "pleurisy-like" pain during an acute attack of gonorrheal salpingitis and years later, when the healed residues of the genital infection were operated upon, has found adhesions over the liver.

Today, most gynecologists recognize the relationship of violin-string adhesions over the liver to genital gonorrhea. However, it is not known why the inflammatory exudate tends to localize over the liver. It might be suggested that the adhesions result from a hepatitis, however, this seems unlikely since women do not exhibit signs and symptoms suggesting parenchymatous liver involvement during the acute illness. Others believe that gonococci are transported to the diaphragm and thus to the liver via retroperitoneal lymphatics and veins. However, for gonococci to be disseminated via the blood vessels and lymph channels seems unlikely and would be at variance with their usual mode of spread through the genital tract. It seems more probable that the adhesions over the liver are mute evidence that a generalized peritonitis complicated the acute salpingitis. Generalized peritonitis was suggested as the probable explanation for these adhesions in Curtis' original paper. The manner in which gonococci spread from the lower genital tract to the peritoneum is along contiguous surfaces, namely, from endocervix to endometrium, endosalpinx, and pelvic peritoneum. Consequently, in more severe or more virulent infections it would not be surprising if the organisms spread throughout the

entire abdominal cavity and produced an inflammation of all serosal surfaces.

Granting that the gonococcus causes an acute generalized peritonitis more frequently than has previously been appreciated, why should the resulting adhesions be restricted to the pelvis and the surface of the liver? By the very character of the adhesions it must be assumed that the gonococcus usually is responsible for only slight serosal damage. Dr. Barry Anson, of our anatomy department, has suggested that modest acute inflammation of the peritoneum is likely to result in subsequent adhesions only over immobile structures. Consequently, after a severe gonorrheal infection of the upper genital zone, one might expect to find adhesions over the liver which is immobile and in the pelvis; there might also be a few adhesions around the spleen which has more mobility than the liver and around the appendix and cecum, which are relatively immobile.

I am not enthusiastic about surgical attempts to open occluded fallopian tubes for the relief of sterility. If the tubes are sealed at the fimbriated ends, one can expect that about 30 per cent will remain patent after salpingostomy. If there is obstruction in the isthmic or interstitial portions, plastic operations are almost certain to fail.

If one removes both fallopian tubes, the corpus of the uterus also should be removed. Some contend that the uterus has a function of internal secretion; I doubt if this has been proved. If the tubes are absent, the patient is sterile and the uterus has been deprived of its function; furthermore, we have found that many women eventually suffer from uterine bleeding after a bilateral salpingectomy. Consequently, we now advocate hysterectomy whenever both tubes are removed; in the long run, it is the more conservative procedure.

If one ovary is diseased and the other one is normal, the diseased ovary should be removed *in toto*. I am opposed to the common practice of incising, aspirating, and excising cysts from ovaries, because an ovary does not react kindly to surgical trauma; it tends to become scarred, cystic, and adherent and often is the site of continuous pelvic pain. By the same token, if all of one ovary must be removed and most of the opposite ovary must be resected, then we believe that all of both ovaries should be removed. Young women, for whom only a small portion of one ovary can be saved, tend to suffer for years after such an operation; not only do they suffer from pelvic pain at the site of the ovarian stump but also are constantly harassed by mild but "never-ending" menopausal symptoms. Under these circumstances, all ovarian tissue should be removed, even though the patients are plunged precipitously into the menopause. They seem to recover more promptly from this type of surgical menopause and they are free from pain. We have learned that bilateral oophorectomy for this group of young women is the less radical procedure. Endocrine therapy has proved most efficacious in relieving menopausal symptoms. I am convinced that women will be essentially free from hot flashes and other disagreeable manifestations of the change of life if given an adequate amount of estrogenic hormone. However, one must administer relatively large doses to many patients if they are to obtain the desired results.

THE 1939 CLINICAL CONGRESS

THE METAMORPHOSIS OF THE SURGEON

HOWARD C. NAFFZIGER, M.D., F.A.C.S., San Francisco, California

THE opportunity of making what may be termed a commencement address is fully appreciated and highly valued. Representing a profession which is not notable for its oratorical gifts and which is usually singularly inarticulate, one approaches such a presentation with considerable temerity. There is comfort, however, in knowing that, contrary to the custom in scientific circles, no immediate public opportunity will be allowed for discussion.

It would seem to be a fitting time to appraise certain trends in surgery. Since the beginning of this century, the place of surgery in the whole field of medicine has undergone a profound alteration so that the former man of handicraft has become a diagnostician, a most essential therapist, and an investigator of some merit. During this same period, medicine as a whole has developed to the extent that it must be considered not as one profession but as a number of professions, the intimate relationship of which must be fostered and maintained, for not only are they dependent on each other but they have a common goal. It behooves us to recognize the weaknesses inherent in our method of advance and to avoid pitfalls insofar as our foresight permits.

The American College of Surgeons has made its concern certain standards of attainment for the surgeon and also has worked consistently for the improvement of the environment in which his work is done. Membership in this organization, while a recognition of your capacity, is at the same time an enrollment in a group which has certain aims which you can support and further and for which all of us must plan. Its potentiality depends not upon the establishment of monuments but rather upon the kinetic drive of all interested in the future of our profession. Education, training, and facilities are among our principal concerns. In its officers, board of regents, directors, library, and even its multiplicity of committees, this College has counterparts in our many universities and other schools of education. As in them, our concern is with the search for truth and the pursuit of knowledge, but, in addition, we have the specific aim of turning them to the advantage of the surgical patient. This is our reason for existing. From time to time a consideration of the changes occurring in medicine will affect our course of procedure and our methods of operation.

Our concern must be not only with sound practice, which has grown from knowledge gained in the past, but with plans to further that progress. A clear view of our destination prevents the charm of attractive trails and sidepaths from distracting us on our journey. The beginner in the field of medicine is impressed with the vast bulk of accumulated medical knowledge and is appalled at the prospect of acquiring any considerable part of it. The numerous subjects and courses and the mystic maze of library stacks contribute to a feeling that here is represented a vast fund of medical wisdom, fixed and substantial. His is the task of engulfing and digesting a required amount, so the poor student protrudes a tentative pseudopodium toward it. Like the ameba, the more stimulation he receives the more he will surround, but the quality and rate of his digestion vary considerably. Later in his studies and in practice he realizes that this inherited trust fund of medical bequests from the past is not complete. Often it does not contain the final word and he notes that when any subject is pursued the limits of our knowledge in it are soon reached. There lies opportunity

From the Department of Surgery, University of California Medical School.

Address of the retiring president, presented before the Clinical Congress of the American College of Surgeons, Philadelphia, October 16–20, 1939.

for individual and independent inquiry, for exploring unknown territory, and for advancing knowledge. In the accomplishment of this it has been said that fortune favors the prepared mind. Foresight and proper groundwork are essential. As our individual lives are determined by our adaptability to our environment, so in the life of surgery we must consider those factors which bear upon its relationship to the entire field of science as well as to our social organization. The increase of surgical therapy has brought increased responsibility to the surgeon. When we realize that two-thirds of the patients in our general hospitals are surgical patients, our immediate responsibility is obvious; but quite beyond this is the added obligation of carrying forward the progress in a correspondingly large part of the entire field of medicine and of using our opportunity to improve the science and the art of surgery.

You have, in the judgment of your fellows, attained certain standards of knowledge and proficiency based upon the facts acquired by our scientific forebears and the skills of your teachers. It is wholesome for each of us to realize, however, that inheritors deserve little credit and that our followers will appraise us only as creators. Admiration and inspiration come from a knowledge of and familiarity with the great contributors to science in the past. At present, the abilities of any capable surgeon to diagnose and to treat are so far in advance of those attained by the very greatest surgeon of a few score years ago, that we may be tempted to consider the past as a convenient backdrop for the stage upon which we display our accomplishments of today, rather than to derive sufficient stimulation to urge us on to contribute whatever we may according to our capacities.

Medicine progresses through the basic sciences, physics, mathematics, chemistry, biology, and numerous others. It may be likened to a growing stream. The first springs feeding it arose in the far distant past and to their flow additions have come from these many scientific sources. In the last 400 years, comprising the development of modern scientific medicine, the stream has become a great river. As students, we acquire some knowledge of its origin, some familiarity with its substance, and on it we embark as practitioners with equal opportunity. All are carried along to some extent, but we quickly become scattered, and real progress depends upon aptitude and perseverance. In no field of human activity do the voyages of exploration carry more allure. For each there is the opportunity to direct his own course, contribute to his own progress and, in the spirit of adventure, search new horizons.

This onrushing torrent threatens to overwhelm us at times as we appreciate our inability to familiarize ourselves with its vast extent. Modern scientific medicine is but four centuries old, less than six lifetimes of three score years and ten, and modern surgery is scarcely 60 years of age. The surgeon of the short robe has gone far. Sixty years ago the practice of medicine was in the hands of the general practitioner. Surgery was limited in amount and represented but a small part in the treatment of the sick. Though specialism began in antiquity, surgical specialists, for the most part, did not exist even as late as the beginning of this century. Up to this time it was within the capacity of a well-trained internist to familiarize himself with all the instruments of diagnosis and to acquire the skill needed to use the armamentarium, the cystoscope, ophthalmoscope, proctoscope, esophagoscope, x-ray, and to perform spinal puncture. How impossible it would be in the present day for any one person to familiarize himself with all the available techniques! Since that time, the various diagnostic methods have become so refined and elaborated that today the otologist, the urologist, the radiologist, the ophthalmologist, the thoracic surgeon, the neurological surgeon, or other specialist must be called upon for the complete studies required in the various fields. With these advances the specialists have acquired greater diagnostic ability and can be credited with advancing the knowledge of pathology and physiology as well as operative treatment in their special fields, so that they have made these activities their own. Such developments have rendered the physician of the present day dependent upon the findings of those who have more advanced and specialized knowledge than he possesses, as well as the special technique.

General medicine, as contrasted with surgery, is occupying a gradually narrowing sphere. Such a trend has its implications for the surgeon or the surgical specialist in that he must assume the broad responsibility for the welfare of his patient rather than for a narrowly viewed surgical condition. Only a few years ago the general practitioner saw the beginning of a disease and perhaps was aided in diagnosis by the internist, while the specialist was consulted, finally, only for treatment. At present a specialist is required in diagnosis and many diseases are recognized in their earlier stages. The existence of this development has been reflected in the attitude of the public who, in the presence of an abdominal emergency or of disorders in some particular part, attempt to seek the appropriate specialist directly. It is fortunate for surgery that the acquisition of technical methods and diagnostic skill has led, in the hands of so many, to an interest sufficiently detailed to permit the furtherance of our knowledge in its basic cognate sciences. This knowledge has permitted the operator to metamorphose into the surgeon who considers the operation but one item in the care of his patient and to whom the correct diagnosis, well-judged preparation, and interested and intelligent aftercare are as important as the operation itself and are equally his responsibilities. Attributed to the great surgeon, Lord Moynihan, is the statement that he liked to consider himself a physician who had sometimes to employ surgery to cure some of his patients.

Much, however, may be said of the disadvantages of such a scheme of specialism and it is our concern to meet and correct them. As noted before, the increase in medical knowledge is such that medicine can no longer be regarded as a single profession but must be considered as a number of professions developing from a common trunk. In many communities, for example, general surgery concerns itself largely with little more than the upper two-thirds of the abdomen and the neck. We must recognize, therefore, the growing spheres of activity in all of the surgical specialties and yet remain alive to their consanguinity. The mutuality of interest of these children of common parentage is evidenced in the American College of Surgeons, and the bonds uniting them should be strengthened. All of them have a common aim—the welfare of the patient; but the difficulty of keeping this clearly in mind when specialism has become too narrow is well attested by the numerous pleas of medical educators to treat the patient as a "biologic entity" or a "psychosomatic unit," rather than by isolated organs or parts. It seems obvious that specialism will increase as long as men continue to select and to pursue their special interests, and furthermore that it has become a scientific and practical necessity.

The trend in all of our larger cities is toward greater specialization, and also in many of the cities of secondary size medicine has become narrowly divided. With the increasing number of specialists who are being trained, and for economic reasons as well, it is evident that all of the specialties will be represented soon in still smaller communities. With increasing population and greatly improved methods of transportation, only a few communities will be so small and so remote that they must of necessity be served only by general practitioners. The field of the specialist in the future will lie in the areas which have, within a radius of 15 or 20 miles, a population of 20,000 or more. It seems entirely possible to me that better service may be rendered under such conditions than can be given by the general practitioners now serving these sections.

Both the strength and certain weaknesses of modern medical education, a development of the present century, have become apparent. It is not so long since the aspiring medical man attached himself to a practitioner as preceptor and served as office boy, hostler, assistant, and companion while he carried on his medical reading, and this period was succeeded by a limited course of lectures and the receipt of a degree. A great advance was made when premedical requirements were extended to include chemistry, physics, biology, and languages, and certainly this preparation for medicine has greatly advanced the understanding of the medical student. Combined with a lengthened medical course, including firm grounding in preclinical and clinical subjects and laboratory work, this regimen has resulted in the development of better prepared practitioners.

In more recent years, with lengthening postgraduate training, still higher levels of proficiency are being attained. The benefits and advantages of such an educational plan are too apparent to require special comment, but what may be said of any weaknesses which have developed? It has become plain that such a program of preparation for medicine as is required in premedical work is reasonable for the average student. One weakness, however, lies in the concept that preparation and training should be the same for all men, without taking into account their individual strengths, their individual interests, and their individual aptitudes. In our educational scheme, *breadth* of background has been stressed in preparing our men for medicine. As a result, those entering medical training have achieved this, at least to some extent, while only a few have acquired *depth* of knowledge in any one of the subjects covered.

The introduction to the basic sciences contained in a premedical course involves no great familiarity with the subjects; it requires, in fact, the minimum which will permit an understanding of the courses which follow. Men have varying interests and the medical profession attracts men of widely different types of mind. We recognize that progress in medicine is dependent on the increases in knowledge arising in such basic sciences as physics, chemistry, and the biological sciences and the application of such knowledge to medical requirements. Yet we have not encouraged the admission to medical college of those who have depth of knowledge in these sciences and who are familiar with recent progress in them. The mathematician, the well prepared physicist, the able chemist, or the psychologist who is attracted to medicine finds great fields of application for his knowledge, but these opportunities are closed to those of us not so prepared. Can we not offer inducements to attract such men into medicine?

An analogous situation appears in postgraduate training. During the early days of modern surgery, late in the last century, the immediate necessity for the budding surgeon was a knowledge of anatomy, for surgery is applied anatomy. Such knowledge is an essential part of the equipment of the surgeon, for without this local geography at his fingertips he would be an unwelcome explorer in the human body. During the early period of surgery, then, anatomy was stressed; the entrance into the profession was by the anatomical route. During this time, the details of operative approach and exposure, technical advances, and instruments adapted to the task were the common contributions to surgical progress. As more general agreement developed on the anatomical aspects of these procedures, and with the adoption of accepted methods, attention broadened from the exclusively anatomical viewpoint, and the importance of surgical pathology was recognized, then emphasized, and now has become incorporated as a necessary and most highly valued part of the training of the modern surgeon. This is said with the full knowledge that even now preparation in this subject is too often woefully inadequate, for its importance cannot be overstressed. As additional background for surgery, our best graduate training schools also insist upon a period spent in the experimental laboratory, which ordinarily implies training in some branch of physiology. Not a little of the prominent place that surgery now occupies is due to the recognition of the necessity for and insistence upon such training in this triad of preclinical subjects for men who expect to become surgeons. These fields are receiving attention and opportunity is not lacking for contribution in them.

A point that I wish to make, however, is that our present scheme of premedical and medical education and graduate training tends to be standardized to the point that we cannot always take full advantage of the capacities and special aptitudes of the men entering our profession. I wish to emphasize again that the advance of medicine depends upon the contributions made by the application of fundamental knowledge coming from the basic sciences and that, while our men entering medicine have some breadth of knowledge with a smattering in each of many subjects, only a few enter with a sufficient depth of knowledge in any one of them to utilize their information in the application of the recent advances to medical needs and medical advancement. Although our plan of premedical training has resulted in a vast improvement in the quality

of medical practice, I cannot but feel convinced that the progress of medicine as a science, in contrast with practice, would have been furthered even more had we admitted to our medical schools men who had majored in one of the basic sciences and had acquired depth of knowledge in some one branch, as well as sufficient breadth in several, to utilize fully their medical teachings. Our profession will be immeasurably advanced if we can induct into it men with profound knowledge in physics, psychology, chemistry, mathematics, and each of numerous other fundamental sciences. To men in medicine who have a special interest in one of these fields there is great promise in furthering that knowledge, for the applications to medicine of recent advances in science lag many years behind, far longer than they need to do if this intimacy of interest can be attained. Many of us can recall occasional instances in which an engineer or chemist became interested in medicine and, with his eyes thus opened, his energies permitted vast dividends in accomplishment which are impossible to those not so prepared.

Likewise, in the field of graduate training in medicine let us not attempt to standardize the preparation of all men and restrict them to certain minimum requirements in any specialty. Anatomy, pathology, and physiology are stressed, and rightly so, but for the student of particular ability and some special interest, let us be in a position to encourage what may seem to be an immediate divergence from his ultimate aim, for by such means progress will be assured. In the fields of biochemistry and bacteriology, how many surgeons can we name who have sufficient basic knowledge of these subjects to prosecute investigations intelligently? Yet the opportunities for the surgeon to apply such detailed knowledge are on every hand.

Not all of us have an absorbing interest in a basic science or a preclinical subject. Most of us find more appeal in the recognition of disease and our ability to treat it. The able clinical surgeon can, by thoroughness and careful study of his cases, contribute largely to surgical progress. His observations and inquiries point the way for experimental and laboratory investigation.

I urge, however, that there is a smaller number with special talents whom we must endeavor to recognize and encourage. I refer to those who may be induced to enter medicine after having had training in a basic science and also those who, in the period of graduate training for surgery, may be induced to separate themselves temporarily from clinical work in order to ground themselves deeply in one of the preclinical subjects. We are familiar with the contributions from the anatomist surgeon and the surgical pathologist; physiological contributions of the first order have come from experimental surgeons. Equally great opportunities lie ahead for the well trained surgeon who is also a biochemist, a bacteriologist, or an immunologist. Let us foster, where possible, the development of such men. Great store may be laid by them and from such sources will surgery be strengthened. Experience has shown that an intimate relationship of the departments representing various sciences mutually strengthens and aids each. It has likewise shown that when these viewpoints are brought together in the mind of a single person, the possibilities of the application of such knowledge to medicine and surgery are greatly enhanced and hastened.

The artist may express his thoughts and his emotions through the deftness of his hand; the scientist, by experimental methods, brings forth the children of his brain; by his acts the humanitarian evidences the greatness of his heart. To each of us, as a surgeon, belongs the great privilege of membership in the profession in which, as in no other, are combined all of these qualities of head and heart and hand.

THE 1939 CLINICAL CONGRESS

THOMAS A. SHALLOW, M.D., F.A.C.S., Philadelphia, Pennsylvania

NO other meeting, whether educational, medical, surgical, political, or social, has so filled the Philadelphia Academy of Music as that of the Convocation of the American College of Surgeons on October 16, 1939. Among the initiates were representatives from 42 states, Canada, and other foreign countries. Honorary fellowships were bestowed upon Surgeon General James Carre Magee, of the United States Army, Surgeon General Thomas Parran, of the United States Public Health Service, and Dr. Eugene Pólya, titular extraordinary professor of surgery, at Peter Pázmány University, Budapest.

The importance of all the features which make up this Clinical Congress was clearly appreciated, therefore, it was the desire of the Committee on Arrangements in preparing the program to continue the excellent example set forth by previous Congresses. Representatives from all Philadelphia and suburban hospitals were invited to participate and a committee was formed to present all the surgical features which would be of interest. In this way, it is believed, all available material was obtained.

For many years surgical organizations had for their stock-in-trade the ability of their members to operate skillfully and to be dramatic. However, it has been the aim of the American College of Surgeons to put an end to these histrionic demonstrations and in their place dry clinics and panel discussions have been substituted. Judging by the attendance, one can say with certainty that these types of presentation are rapidly gaining favor. In addition, there were afternoon symposia on the subjects of fracture, cancer, urology, diseases of the respiratory tract, obstetrics and gynecology, and graduate training. These discussions attracted large audiences who evidenced great interest in these topics.

Chairman of the Committee on Arrangements.

The evening sessions, which embraced a variety of subjects, brought to light numerous advances in the fields of medicine and surgery. The papers covering the work on vitamins, especially on the influence of vitamin K in its relationship to the prothrombin time, were worthwhile contributions. Vitamins, it was demonstrated, reduce mortality and morbidity, placing many jaundiced patients in a relatively safe condition for surgery. Other papers on vitamins indicated that almost 40 per cent of patients who enter the hospital border on scurvy; and this disclosure should open the field for the proper investigation into dietary deficiencies.

It was also proved conclusively at this meeting that surgery is more than a mechanical art and that the mortality and morbidity of surgical patients have also definitely declined. Patients are no longer rushed into hospitals and operated upon immediately. They are properly studied and, within the past few years, properly prepared for surgical measures. The papers on pre-operative preparation of surgical patients were among the most notable features of the meeting.

One of the outstanding contributions was a discussion on the diagnostic value of the peritoneoscope in demonstrating the location of lesions and their operability, the presence of metastases, and even the opportunity to study tissue removed by means of this instrument, which has been a definite safeguard for potential surgical subjects, saving many with incurable conditions from needless operative procedures and permitting them to be treated expectantly.

One of the highlights of the Convocation was the annual oration in surgery delivered by Dr. Evarts Graham,[1] of St. Louis. It is interesting to note that Dr. Graham was one of the recipients of the John Scott Award in 1937 for his notable contribution to a more accurate diagnosis of biliary tract disease. By

[1]The address by Dr. Graham will appear in a later issue.

his ingenuity he was able to apply that which was lacking in pure laboratory methods and to demonstrate the hitherto unrecognizable disorders of the liver and gall bladder. In his oration Dr. Graham discussed intrathoracic tumors and clearly pointed out that major surgery of the chest requires more than operative skill and courage. The anatomical and physiological problems which are constantly presenting themselves were ideally portrayed by him, and all who heard him profited by his excellent discussion. At the election of officers which took place during the annual meeting on Thursday, October 19, Dr. Graham was chosen president-elect.

The president for the ensuing year is Dr. George P. Muller, of Philadelphia. The retiring president, Dr. Howard C. Naffziger, of San Francisco, who has played no small part in the advance of neurological surgery, struck a new chord in his address. He stressed the need of depth as well as breadth of knowledge. He urged that scientists in other fields, such as chemistry, physics, and mathematics be encouraged to enter the fields of medicine and surgery in order that the depth of their own scientific knowledge be utilized for the advance of medicine and surgery.

Surgical films were presented each day during the Congress and, as in previous years, this concrete means of presentation proved a great favorite. It was gratifying also to witness the growing interest in the scientific exhibits which deal with subjects related directly to the various activities of the College; and coupled with these exhibits were those of a number of national organizations.

Another outstanding feature was the lectern and desk, which were on display at the Bellevue-Stratford Hotel. These are to be presented to the Royal College of Surgeons of England in appreciation of the gift of the Great Mace which was given to the American College of Surgeons by the Consulting Surgeons of the British armies at the close of the World War.

The Congress was characterized by good fellowship and the interest and co-operation of the various surgical units of the Philadelphia hospitals and hospital managements; and the Committee on Arrangements wishes to take this opportunity to thank all who helped to make this meeting such a success.

TWENTY-SECOND ANNUAL HOSPITAL STANDARDIZATION CONFERENCE

MALCOLM T. MacEACHERN, M.D., Chicago, Illinois

HOW widespread have been the benefits of Hospital Standardization is particularly perceptible each year during the hospital conference, when from all parts of the United States and Canada hospital executives are assembled to discuss their problems. No matter what these may be, there is evident satisfaction in the feeling that a central authority exists through which the sometimes divergent views may be sufficiently reconciled to make possible the working out of standard procedures which all may advantageously follow. Much of the work of Hospital Standardization has been accomplished through this process of facilitating expression of opinion by the people in the field, who need only guidance and a centralizing force to help them solve their own problems. Through choice, hospitals have elected to follow the Minimum Standard, and through a democratic ideal of encouraging full discussion and hearkening to all ideas expressed, the College has tried to make this hospital activity a genuine service to those directly concerned, namely, the hospital, the doctor, and the patient.

In extending the helpful influence of Hospital Standardization, the College relies to a great degree upon the enthusiasm of its individual Fellows. It is they who are responsible for keeping this force operating with maximum effectiveness. The surgeon can stimulate the hospital or hospitals with which he is connected to exemplify in practice the most up-to-date interpretation of the principles set forth in the Minimum Standard. And he can bring to the attention of the College, from his close contact with the actual needs, his ideas on how the Hospital Standardization program may be made increasingly helpful to hospitals.

There should be a large measure of satisfaction to the Fellows of the College in the expressed reactions of members of the hospital profession to the service being rendered through the hospital program. Several examples may be taken from the talks at the 1939 conference. The rehabilitation of a large county hospital which was in bad repute, declared a member of its board of trustees, was quickly accomplished "through the joint efforts of representative citizens, the medical profession, local hospital administrators, and the strict but helping hand of the American College of Surgeons." The progress and advancement made by the hospitals in Canada during the past 20 years, said another speaker, "are due, in no small measure, to the result of Hospital Standardization and to the great interest stimulated by, and the supervision given by the College." The superintendent of a small hospital referred to the College as a "beacon light" for that type of institution.

The small hospital undoubtedly represents a field in which the hospital program should be intensified. In the opening address at the conference, President Howard C. Naffziger of the College referred to the need, saying:

> "In the hospitals recommended for graduate training for surgery we are dealing with the conspicuously bright scholars of the hospital world. There is a great deal of promising material also among those who for one reason or another lag near the foot of the class. Outside influences may be responsible for their relative inability to keep up with today's standards. Public ignorance and indifference are factors to which blame for their plight may often be traced. A program of public education in hospital service will help the small hospital, and to such a program all hospitals, and organizations such as the College which have to do with hospitals, should contribute. For the weaker institutions tend to handicap the strong. Hospitals have come a long way in the twenty-two years since the first Hospital Standardization Conference. They have a long way yet to go before the hospital needs of every type of community are met adequately.
>
> "Since approximately 94 per cent of all hospitals having 100 beds and over are approved, evidently

the deficiencies and inadequacies are to be found mostly in the small hospitals. By helping the small institutions to attain higher standards, as it is constantly doing, the College is making the benefits of Hospital Standardization felt in communities which may be far outside of metropolitan areas. The small hospital, however, must merit approval before it is granted, for no concessions can be made in the fundamental principles of Hospital Standardization."

There can be no doubt that many hospitals in the smaller communities are having a difficult struggle to keep operating, let alone meet high standards of service. Yet there is agitation to build more hospitals, in rural and semi-rural communities, to be supported by taxation. Obviously, if the amounts proposed for supplying new facilities could be appropriated instead to rehabilitation, and, if need be, to the extension of existing hospitals, the net result would be more and better hospital service to raise the health level of the community. To duplicate existing facilities is not to increase hospital service, because a factor of competition would enter which would almost inevitably force the voluntary hospital out of existence in favor of the tax supported institution. The community would then have changed only its type of hospital service not the amount. This condition would not hold everywhere, of course. There undoubtedly are a few instances in which a community should have a new hospital, because in the distribution of hospitals it was for one reason or another neglected. On the whole, however, a hospital is conveniently accessible to most people; in fact, it seems that but 13 counties in the United States are more than 30 miles distant from a reputable hospital, and that only 5 of these 13 counties have a population of more than 5 people per square mile.

The real problem is to bring these existing hospitals in rural and semi-rural communities up to higher standards, to increase their bed capacity if needed, and to expand their out patient services. Mainly, the approach to a solution of this problem is through educational channels. The people of the entire area which the hospital may be developed to serve should be awakened to the need for supporting it, and apprised of the ultimate economy of conserving the hospital resources they already have. No doubt, aid from tax funds should in many cases be given, because the load of needy patients will be greater than the hospital and its private benefactors can bear. But in so far as practicable the institution should be supported locally, because of the many advantages of local control.

Thus, while the College and its fellowship are proud of the growing number of approved hospitals—reaching 2,720 in 1939—they are also keenly aware of the many current problems with which hospitals are faced. To help in their solution is a continuing aim of Hospital Standardization.

GRADUATE TRAINING FOR GENERAL SURGERY AND THE SURGICAL SPECIALTIES

DALLAS B. PHEMISTER, M.D., F.A.C.S., Chicago, Illinois

FEW activities in which the American College of Surgeons has become engaged have stirred so much interest as the program of graduate training for surgery. In the evolution and development of this field there has been considerable confusion, little or no correlation, and, in many instances, radical differences of opinion on the subject of how a surgeon is to be trained. The chief direct sufferer during this process of development has been, of course, the aspirant to a surgical career. Indirectly, the whole profession, and frequently the patient and the public, have suffered with him.

Surveys and analyses thereof by the College, under the direction of the Committee on Graduate Training for Surgery, have helped to bring to light the extent of the confusion and to disclose some of the basic causes for disagreement, thus awakening the profession and hospitals to the need for determination of standards. The College, through the formulation of fundamental principles for graduate training in surgery, has been able to provide a general guide at least for the development of acceptable programs of training.

Recognizing the demand for more formal training of the surgeon, the College in 1936 raised the requirements for fellowship. To comply with the resolution adopted May 10, 1936, candidates for fellowship must have spent 2 years or more in surgical training in acceptable hospitals following a year of hospital interneship after graduation from medical school. This new requirement affects applicants whose qualifying medical degree has been obtained since January 1, 1938, or, in the case of graduates of medical schools, which withhold the degree until after the fifth year of hospital interneship, the effective date is January 1, 1939.

The College was therefore obligated to lend every effort toward encouraging acceptable programs of training for its future fellowship. There was available to prospective Fellows, however, no source of complete and accurate information on the opportunities for graduate training in general surgery and the surgical specialties which would meet the new requirements for candidacy. Teachers and preceptors of the medical student or interne could not always offer him proper guidance in planning a satisfactory course of training. Their knowledge was often limited to their own experience and the few training programs with which they had become acquainted by observation or hearsay.

Not the least of the accomplishments of the graduate training work of the College has therefore been the collection of information on a large number of plans, and its dissemination to those whose advice and guidance is sought by the medical student, the interne, and the more recent medical graduates, eager to acquire further education and training in surgery. In the past year or so there have been published in the *Bulletin* of the College, which is distributed to all Fellows, junior candidates, and approved hospitals, detailed descriptions of the plans of 42 institutions for graduate training in general surgery and the surgical specialties. In the aggregate, this constitutes an impressive store of information on the subject. It has already proved to be of the utmost value to present and prospective members of the surgical profession and to hospitals seeking to gain ideas for bettering their present programs or for instituting acceptable plans in cases in which no program had yet been adopted.

To this factual data already published there will be added from time to time descriptions of other plans, and possibly all can be combined eventually in a revised form under one cover to constitute a convenient source of reference covering acceptable programs for graduate training in surgery. Obviously, easy

Chairman of the Committee on Graduate Training for Surgery.

access to such information is an incentive to planning careers in surgery, and certainly it is desirable in the beginning to encourage a definite plan of training rather than permit the medical graduate to drift from one hospital residency to another or into practice, only to discover later his leaning toward surgery which he can then indulge only at much greater comparative expense because he must sacrifice income. At that late date it has also become more difficult for him to obtain a satisfactory appointment for training.

Discussions of various aspects of graduate training have been published in a number of issues of the *Bulletin*. Most of these have been papers that have been given at the graduate training symposia held during Clinical Congresses. The January, 1940, *Bulletin* contains the papers presented at the 1939 Congress, which covered the general subjects of basic science requirements, evaluation of training, and organization and supervision of the educational program.

Also in published form, in the October, 1939, issue of the *Bulletin*, are revised "Criteria for Graduate Training for Surgery," an outline of the fundamental principles, and a list of 179 hospitals and/or other educational institutions in the United States and Canada which are conducting approved programs.

Thus in its contribution to the literature on the subject, in addition to its direct influence in promoting graduate training, the College has performed a valuable service. The value of the work is enhanced by the fact that theory and opinion have been subordinated to the detailing of findings revealed by actual personal surveys, and to analysis and evaluation of these findings as they bear upon the improvement and better correlation of training programs. Study of actual needs and of actual conditions has preceded every step in the College effort as it has advanced to the point where it has been possible to issue an approved list and to describe acceptable plans. Such study will continue to govern the constant consideration and reconsideration of plans for approval and decisions as to further courses of action.

It would appear that one object of the effort is being realized already in that the number of training places has been increased. If the present rate of increase is maintained for a few years, the needs for opportunities for training, numerically speaking, will be adequately met before long. There will remain, however, ample need for continued exercise of influence, in co-operation with other groups, upon the quality of training afforded. If the art and the science of surgery are to be kept on their onward and upward course, there can be no end to our active concern for the enforcement of constantly rising standards governing the education and training of the surgeon.

FRACTURES AND OTHER TRAUMA

THE AMBULATORY TREATMENT OF FRACTURES OF THE LOWER EXTREMITY

FRASER B. GURD, M.D., F.A.C.S., Montreal, Canada

ABOUT the year 1880 Owen Thomas, of Liverpool, attempted to permit patients who had suffered fractures of the lower extremity, more especially of the femur, to walk with the help of the caliper, which today bears his name, before sufficient time had elapsed for firm union to take place. Thomas' important contributions seem to have been forgotten by surgeons until the time of the war when, under the stimulus of that master surgeon and great gentleman, Sir Robert Jones, the importance of both traction in the treatment of fractures and the value of early protected weight bearing with the help of Thomas' apparatus again became recognized.

It was a simple forward step, following the employment of the Thomas knee splint as a walking caliper, to have suggested the use of a short caliper, reaching not to the tuberosity of the ischium but to the tuberosities of the tibia, as a convalescent appliance in the treatment of fractures of both bones of the leg, about the ankle joint, and of the foot.

The methods introduced by Thomas and Jones were primarily recommended in order that patients, in whom union of bones had progressed to a stage of minimal consolidation, might be able to bear weight without the risk of bending or torsion strains being transmitted to the site of the new callus deposition. Apparently, the first effort to permit weight bearing upon the fractured leg before such consolidation had taken place was attempted by Dollinger, of Budapest, who in 1893 described a method of applying plaster-of-Paris with this end in view. Dollinger recognized the fact that it was possible to apply plaster to the unpadded limb so that weight might be borne from the bottom of the plaster to the tuberosities of the tibia. In order that no weight whatever should be borne by the foot or leg below the site of fracture he placed a layer of padding beneath the foot and between it and the plaster covering the sole.

Immediately following the first phase of the war, that is about the end of 1918, my attention was directed to the contributions of Delbet, of Paris, who in 1915 had published the description of a method for reducing and fixing fractures of the leg and about the ankle joint. We employed Delbet's method as a convalescent protective apparatus in the case of fractures of both bones of the leg after union had sufficiently consolidated to make it appear reasonable that some weight bearing upon the limb might be attempted, but earlier than it was deemed advisable to run the risk of either bending or torsion strains. An attempt was made to apply Delbet's dressing in both its original manner and in the form as modified by us in the early treatment of fractures especially about the ankle joint. It was found, however, that if Delbet's apparatus was applied soon after the date of injury the limb became dependent, swelling occurred in the foot and at the site of the windows created between the upright bars and the 2 cuffs. In consequence, if the patients attempted to walk not only was there pain but linear ulcers were likely to be exhibited over the tendo achillis, over the tendon of the tibialis anticus muscle, and at the edges of the windows.

The success which attended the employment of Delbet's dressing in the support of incompletely united fractures of the leg impressed me with the feasibility of employing the upper surface of the upright cone, represented by the malleoli, and the inferior surface of the inverted cone, represented by the tuberosities of the tibia, as a means of transmitting weight from the former to the latter. Early in 1919, therefore, I began the application of plaster without padding in fractures of the foot, about the ankle joint, and of the leg. At the time I was not familiar with the contributions of Dollinger and consequently was not misled into the employment of a pad beneath the foot between it and the plaster.

From the Montreal General Hospital.

Fracture oration presented before the Clinical Congress of the American College of Surgeons, Philadelphia, October 16–20, 1939.

During the Clinical Congress of the American College of Surgeons in Montreal, in 1926, a number of patients suffering from fractures about the ankle joint and of the os calcis were demonstrated walking in unpadded plaster casts a few days following receipt of injury. Although upon several occasions prior to 1928 addresses were presented before a number of medical societies in which the application of unpadded plasters to permit early protected weight bearing were read, no publication was made describing the technique until August, 1928, at which time I published a paper which had been read before the Academy of Surgery in Philadelphia on March 5, 1928.

These remarks are made at this time because I believe it is true that I have the right to priority in the employment of unpadded plasters in order to make it possible that early protected weight bearing be carried out by patients soon after fractures of the leg, foot, or ankle have been suffered. Since 1928 a number of articles have been published in which the indications for and the contra-indications against the method of application, and the advantages and disadvantages of the method have been described and discussed.

As I have reported on many occasions a description of the technique which we have employed in the application of the unpadded plaster in the treatment of fractures of the foot and about the ankle joint, the procedure will not be described in detail here. I have also discussed what I believe to be the essential differences between my own technique and those of Delbet and Boehler.

Two essentials are required before an unpadded plaster which will permit weight bearing may be applied. In the first place, accurate reduction should be obtained and, in the second, there should be no swelling of the limb whatever. A third desideratum is that the skin be carefully cleansed. We use for this purpose soap and water, alcohol, and a generous coating of zinc stearate powder. If bullæ have been present, they are treated as indicated and their neighborhood painted with a suitable skin antiseptic.

If the case is seen immediately following injury and before swelling has taken place, it is possible to apply the unpadded plaster at once. Since, however, it is unusual to see cases before swelling or hematoma formation, there is usually a necessary preliminary fixation period following reduction. As a routine in our clinic we have for many years employed for this purpose the pillow splint which has been described previously. This preliminary fixation period lasts from 2 to 12 days. During this time disappearance of swelling from the limb is accomplished by raising the foot of the bed and, in some cases, by means of the assistance of baking and gentle massage.

A discarded silk stocking, which is always available from the waste baskets in the nurses' home, is drawn over the powdered limb. Although we are quite convinced that the method of application of plaster as advocated by Boehler, Griswold, and others, which is characterized by the application of a posterior molded splint first and finished by means of circular plaster is good, we have continued to use a circular cast reinforced by a stirrup-like band. This band strengthens the heel upon which weight will be borne, and also the ankle joint which attempts to move. The band extends to above the junction of the middle and lower thirds of the leg, because experience has shown us that this is the part of the apparatus subjected to special strain.

It is evident that in the application of the circular turns care must be exercised so that no constricting bands of plaster be applied and that no dead spaces exist. Since it is of the utmost importance that there be absolutely no swelling of the limb, we are of the opinion that the latter should not be allowed to become dependent during the application of the plaster. Griswold's suggestion that the patient be prone and the leg be flexed at the knee joint is admirable.

Before the cast has set it is carefully molded about the malleoli and to the upper end of the tibia. The foot is fixed at a right angle at the ankle joint and, depending upon the nature of the injury whether external rotation, fibular flexion or tibial flexion, suitable pressure upon the os calcis and astragalus is accomplished to maintain reduction. The mid foot is flexed so that the first and fifth metatarsal heads are on the same horizontal plane and the longitudinal arch of the foot thus reproduced or exaggerated.

Since we have noted that the majority of patients wearing artificial limbs after amputations of the leg prefer to have some of their weight borne upon the lower border of the patella, we have made it a practice to carry the plaster up to this point in front. The posterior border of the cast is cut away sufficiently to permit flexion at the knee to a right angle. Prolonged experience has proved to our satisfaction that it is advisable to include the fifth and usually the fourth toes inside the plaster; because if the plaster stops at the base of the toes, swelling is likely to occur distal to the edge and painful pressure points are consequently likely to ensue.

As soon as the plaster is dry a heel fashioned from saddler's felt 1 to 1½ inches thick is attached

to the bottom of the cast with adhesive plaster. The patient is then ready to walk without the employment of crutch or stick.

Private patients have been advised to purchase custom-made boots so fitted as to go over the plaster. Such boots are usually so fashioned that they are not particularly noticeable, and consequently the patient is able to go about his business without being conspicuous. In Montreal the cost of such a custom-made boot is between $10.00 and $12.00. For patients who cannot afford such a luxury a cheap slipper-like covering can be made for $1.00 or thereabouts. Hospital patients provide themselves with either a cheap slipper or a large moccasin. In general, it is inadvisable to allow patients to wear a covering containing rubber over the cast since the moisture which accumulates under these conditions is likely to soften the plaster.

In the treatment of fractures of both bones of the leg we have employed 3 methods. By some of our staff and in certain cases skeletal traction in a Thomas or Braun splint has been employed as an immediate method and continued from 3 to 4 weeks or until early union has commenced. In a smaller number of cases we have used traction and distraction by means of heavy Kirchner wires through the upper border of the tibia and either the lower tibia or os calcis. If such cases have been seen before swelling has occurred, an unpadded cast in which the ends of the wires are incorporated is applied at once and the patient is permitted to start immediate weight bearing. This technique has been employed in transverse fractures in which accurate coaptation of the bone ends has been possible.

Anderson and Griswold have obtained satisfactory results by the employment of pins inserted through the upper part of the tibia and the os calcis. Each has designed an apparatus which is employed for reduction and for fixation of limb pending application of plaster to the skin.

In January, 1935, Griswold reported his results over a one year period ending June, 1934. Of 67 fractured legs, the double pin technique was employed in 43. In the remainder, except for a small number of severe compound fractures, manual reduction and unpadded casts were employed without pins. The results were, in Griswold's opinion and with which I heartily agree, extremely satisfactory. He was also able to state that the period of hospitalization including both simple and compound fractures had been reduced to an average of less than 10 days.

Our routine method, however, has been to carry out reduction by means of traction, employing for this purpose what we have considered to be our own modification of Delbet's sling. By means of this sling which grasps the os calcis at the point of attachment, the tendo achillis, and the astragalus just distal to the ankle joint, it is possible for the assistant to maintain traction by means of his body weight transmitted through the upper arm and at the same time to have both hands free for manipulation of the foot.

TABLE I.—LENGTH OF TIME FOLLOWING INJURY AND START OF LOCOMOTION

	Days
Both bones of the leg	18 to 25
Ankle joint—seen immediately following injury before swelling	1 to 3
Ankle joint—seen after swelling has taken place	5 to 8
Os calcis—reduction usually third to eighth day	10 to 16
Astragalus—astragalectomy for crush fractures	5 to 16
Mid tarsal row—cuneiforms, cuboid, and scaphoid	5 to 8
Tarsal bones	2 to 8
Great toe	1 to 8

If swelling is present at the time the reduction is carried out, a single layer of sheet wadding is applied to the limb, particular care being taken that not more than one layer be applied over the upper portion of the tibia or about the malleoli. Circular plaster-of-Paris is applied with the sling in position. Care is taken to mold the plaster accurately to the cone represented by the malleoli and to the upper border of the tibia. The first plaster is applied with the knee joint flexed about 15 degrees and reaches to the junction of middle and upper thirds of the thigh. Since by this technique it is difficult to prevent posterior bowing at the site of fracture unless the foot is kept in moderate plantar flexion, this position is adopted.

When the plaster has set, the sling is removed from the foot in order that pressure points arising from its incorporation in the plaster under tension may not take place. Removal of the sling is usually accomplished without much difficulty by slipping a pair of bandage scissors between plaster and skin and cutting the loops. The whole sling is then withdrawn. Following the removal of the sling a few turns of plaster are applied so that the space in the sole of the foot may be covered.

The patient is returned to bed with the foot of the latter raised a distance of 8 or 10 inches in order that adequate circulation may be established as promptly as possible. On about the twenty-first to the twenty-fifth day the anterior half of the cast is removed and the site of fracture and limb as a whole investigated with special reference to the condition of the skin and the presence or absence of swelling. It is usually discovered at this time that the bone ends are

sufficiently fixed to prevent displacement and to permit movements of knee and ankle joints. At this time we customarily employ gentle massage and baking for a few days and induce the patient to attempt movements of the ankle joint to bring about dorsiflexion of foot to at least a right angle.

As a rule, on the twenty-fifth to the twenty-eighth day following injury we have found that absolutely all edema has subsided and that fixation at the site of fracture has become sufficiently stable to permit dorsiflexion of the foot without any tendency toward displacement or bending. A walking, unpadded plaster is then applied over a silk stocking, according to the technique described for fractures of the foot and ankle, but it is extended to about the junction of the middle and upper thirds of the thigh. Since, on the one hand, there is no necessity for the plaster fitting snugly to the skin above the knee joint, and on the other hand, on account of the ease with which the thigh tissues are molded, no attempt is made to make the plaster fit snugly at this point, 1 or 2 layers of either sheet wadding or flannelette are applied between the plaster and the skin above the knee joint. Just before the plaster finally sets this upper border is turned down so that no cutting edge will be produced. The reinforcing plaster-of-Paris stirrup is carried well above the site of fracture so that strain on the circular plasters at this point will be minimized. As soon as the plaster has dried a felt heel is fixed to the bottom of the plaster as recommended for fractures of the foot and ankle.

We have felt that it is rather important when the patient first begins to walk that he be instructed as to the proper gait to employ. Since the knee and ankle joints are complementary, he is advised that whether the fixation extend above the knee or not no useful purpose is gained by attempting to flex the knee joint in walking. He is instructed to keep the injured limb at all times in front of its fellow so that he steps forward whatever distance is convenient with the plaster encased foot and brings the normal foot up to but not past the injured member.

ADVANTAGES AND DISADVANTAGES OF DIFFERENT METHODS

From the patient's point of view there are many unfavorable features which may follow fracture of one or more of the bones of the lower extremity. These are: (1) Pain and possible shock to the nervous system; (2) loss of time; (3) expense of treatment, with special reference to hospital and surgical fees and possible apparatus; and (4) persistence of disability either for a long time or permanently. Prolonged or permanent disability may be due to deformity, delayed union, nonunion (pseudarthrosis), interference with joint function, contractures and consequent interference with action of muscles and tendons, circulatory disturbance as manifested by swelling and loss of tolerance to low temperatures, and painful foot due to atrophy of bone and ligamentous structures of either acute or chronic type.

Those who are familiar with the technique of plaster application and postoperative treatment of patients who have suffered fractures below the knee believe that the above unfavorable concomitants or sequelæ are in large measure avoided by the use of a technique which permits early protected weight bearing.

Pain and shock to nervous system. Since it is possible for such persons to be out of bed fully dressed and to carry on many or most activities within a few days after injury, the effect upon morale is striking. The natural effects of such improvement in morale are to minimize the incidence of that train of symptoms commonly referred to as traumatic neurasthenia or even that more subtle symptomatology known as sinistrosis.

Loss of time. By means of the application of unpadded plaster to the injured limb it is possible for professional and business men to return to full activity within a few hours after the time of injury in the case of fractures of the foot or about the ankle joint, or within a month in the case of fractures of the leg. The above refers to results in cases in which operative methods in the sense of piano wire or pin fixation are not used or at an earlier date if such methods are instituted (Griswold, Anderson).

Although we have not employed in our clinic any of the methods, especially that of Anderson, which make possible early protected weight bearing in the case of fractures of the shaft of the femur, it would seem that such a contribution as that made by Anderson is the inevitable result of improvements in the treatment of fractures below the knee by a similar technique. Since Anderson's description of his technique seems to prove the mechanical reasonableness of the multiple pin method, and since the results reported by him and the comparatively small number of surgeons who have employed his method are so satisfactory and apparently free from risk, it would seem likely that in the near future in certain selected cases, at least, we will find persons in wide spread parts of the continent returning to full occupation within a few days after having suffered a fracture of the shaft of the femur.

Although immediately following the introduction by Smith-Petersen, of Boston, of the flanged nail there was a somewhat general belief engendered that such fixation would permit early weight bearing, and although, in fact, in many cases the results of partial weight bearing assisted by crutches were satisfactory, I believe I am correct in stating that today the majority of surgeons have reached the conclusion that attempts at walking with weight bearing upon the injured limb in less than 3 to 4 months from the date of accident is inadvisable unless additional methods of protecting the injured bone are instituted.

In addition to business men, clerical workers, physicians, surgeons, and members of the legal profession who, as here indicated, are able to return to their usual activities almost immediately following fractures at least below the knee, housewives and mothers are usually able to carry on with their necessary duties with only a short period of absence from the home. Again, in so far as household activities are concerned the fact that domestic servants have to remain away from work for only a few days in consequence of a fractured ankle or broken foot is of importance both in that the routine of the household is not disturbed and, in so far as the injured individuals themselves are concerned their employment is maintained. Moreover, pupils and students at schools and universities are able to carry on with little time loss. In this connection, too, I should like to express the opinion that contrary to the general belief the value of such young people's time is equally if not more important than that of older persons.

Until such time as Workmen's Compensation Boards and insurance companies have the matter placed before them in an adequate fashion by their surgical advisers it will not be possible for employees to return to work until final consolidation of fractures and return of function has been obtained. Nevertheless, the very fact that with the speeding up in industrial operations the number of accidents is likely to increase will, I believe, make it imperative before long that on the one hand savings to industry and, on the other hand, increased earning capacity on the part of the employee shall draw forcibly to the attention of both commission and insurance company the importance of demanding that patients with fracture at least below the knee be treated in a manner similar to that recommended in this contribution. If, as seems probable, a shortage of labor in all directions in consequence of war activities becomes acute, there will be an added demand for the shortest possible period of lay-off, particularly in the case of skilled workers. Unfortunately, in consequence of the past 10 years of inadequate employment the supply of skilled workers has become lamentably short.

Expense of treatment. Recent data with regard to the expense to the community, the individual, or other organization responsible, have shown that the greater part of the expenditure is on account of hospital erection and upkeep. If improvement in surgical care is to result in better end-results and a shortening of both temporary total and temporary partial disability, there seems to be no reason why surgical fees for the care of individual fractures should in any way be reduced. If it be possible, and it is, to treat 3, 6 or 8 persons rather than only 1 individual with the employment of but 1 bed, it is evident that the erection of new hospitals will be minimized. It is true, of course, that the more intensive the active treatment which is carried out, as is the case when a rapid turnover takes place, the cost per bed per day is increased; nevertheless, in the long run the cost of hospitalization in so far as fractures of the lower extremity are concerned, has been and will be enormously reduced.

Although there will, I believe, always be a certain demand for the employment of those procedures which are grouped under the heading of physiotherapy in a small selected group of cases, it immediately becomes evident as soon as a method of early protected weight bearing is employed that the necessity for prolonged employment of physiotherapy is either completely eliminated or much reduced.

Persistence of disability. With reference to the persistence of disability either for a long time or permanently, and this refers equally to men coming under Workmen's Compensation Commissions and to business executives, professional men, and others, this may be considered under 3 separate headings: (1) total temporary disability; (2) temporary partial disability; and (3) permanent partial disability.

Since total temporary disability is reduced for many classes of persons to the matter of hours or days for fractures of foot and ankle, and approximately to only 4 weeks for fractures of both bones of the leg, this feature of such fractures is in large measure eliminated. This is true although temporary partial disability does, in fact, to a certain extent take its place, although for many persons the disability suffered while the protective plaster is being worn is more theoretical than real. Although permanent partial disability following fractures will never be completely eliminated because the original trauma not infre-

quently causes injuries to essential soft tissues as well as to bones and, although early protected weight bearing will not take the place of skillful early reduction, it is nevertheless true, we believe, that many of the causes for permanent partial disability are avoided by the employment of the unpadded plaster and immediate weight bearing and locomotion upon the injured limb.

CAUSES OF PROLONGED OR PERMANENT DISABILITY

The causes of prolonged or permanent disability have been stated. However, it is in order, I believe, to make the following remarks:

1. It is evident that with regard to deformity immediate skilful treatment with exact anatomical reduction of displacement as nearly as possible is of paramount importance. It is also true that in too many patients deformity, particularly of fractures about the ankle joint, develops secondarily as the result of too early unprotected weight bearing upon the injured limb. Since patients, who are able to carry on more or less completely with their usual occupations, are much less likely to complain of the length of time required for complete consolidation, this secondary cause of deformity is not likely to complicate the progress of the case.

2. The question of delayed union is one which has been discussed in a large measure in the preceding paragraph. I wish, however, to make the statement that in my opinion the fact that in practically all textbooks on general surgery the length of time indicated for sound consolidation in fracture repair is too short. Sufficient attention has not been paid by many surgeons to the differentiation of early fixation by provisional callus at the site of fracture and consolidation of sufficient strength not only to bear weight but to resist torsion and bending strains. There can be no doubt in my opinion that many patients are subjected to operation for bone grafting or perhaps other procedures with a diagnosis of delayed union on account of the optimism on the part of the attending surgeon regarding length of time required for consolidation of certain fractures.

3. Non-union or pseudarthrosis with definite adventitious bursa formation in consequence of liquefaction of the osteoblastematous tissue unquestionably occurs and is exhibited at one stage during the course of bone repair. We all have seen such cases; nor is there any difference of opinion as to the necessity in such cases of somewhat radical interference with a view to removing the tissue between the bone ends and usually the insertion of a bone graft. I believe I am correct in making the statement that the incidence of pseudarthrosis in those patients treated by surgeons, who have become familiar with the technique of early protected weight bearing, has been enormously less than that encountered by surgeons who have continued to treat fractures by other methods. Our long experience of approximately 20 years in the treatment of hundreds of fractures of the ankle joint and leg by means of the unpadded cast and early protected weight bearing has resulted in but one case of non-union, although during the same period many cases of non-union have been referred to us which had been treated by other methods.

In a previous contribution I referred to an article by Kuentscher which unfortunately, so far as I know, has not been confirmed by English or American investigators. In this article Kuentscher indicates that experiments by himself and others, more especially Kompecher, have proved that if during bone repair the new callus is kept under the influence of traction, pseudarthrosis is the result, but if under the influence of pressure bony union may be expected. In other words, by pulling the fragments asunder fibrous union results and by pressing them together bony union ensues. Although in a properly applied walking plaster but little weight is borne upon the bone ends, unless serious errors in technique have been made, there is but little likelihood of distraction.

Many of us are of the opinion that walking upon the fractured limb results in stimulation of bone consolidation in the same manner as that procedure introduced by Owen Thomas and popularized by Sir Robert Jones, namely, that of exposure and hammering the bone ends in cases of non-union.

4. Space limitations do not permit a consideration of the various factors which result in interference with joint function which follow fractures and the more or less inevitable and necessary period of fixation. It would seem evident, however, that at least 2 important factors have an influence upon such unfavorable sequelæ. On the one hand, the peri-arthritic structures, ligaments, tendons, and tendon sheaths, as well as other less specific soft structures have a tendency to contract to the position maintained during the period of rest. It is for this reason that a number of surgeons prefer to employ a method which can be described best as that of early mobilization (de Champonière, Menell and others). The second important reason, in my opinion, for interference with joint function with the development in some cases of actual ankylosis is that of atrophy of cartilage and ligamentous structures which we be-

lieve takes place *pari passu*, with the invariable though usually minimal decalcification of the bones about the site of fracture.

As the result of weight bearing during healing adequacy of the blood supply to the injured limb is usually maintained; in consequence, atrophy of cartilage, ligament, and bone is minimized and loss of joint function due to this cause is avoided. In so far as the tendons are concerned, although no movement is possible in a well applied cast, these structures attempt to move and, in fact, do move within a limited range. In any event it is unusual when fixation is removed to find any considerable loss of joint function. If the position of the joints has been properly provided for prior to fixation, it usually requires only a few minutes of active movement before complete return of function is established.

5. Contractures and interference with action of muscles and tendons has been referred to in the last section. The fact that marked muscle atrophy occurs with shortening of the musculotendinous systems, which are placed at rest during the fixation period, is recognized by everyone who has treated patients with fracture of the lower extremities either in bed or on crutches with a dangling limb. Although a properly applied, unpadded plaster cast so fixes the joints of the limb that practically no movement takes place, such fixation does not prevent contraction and sliding of the muscles and, to a lesser degree, of the tendons. The fact that muscles which are induced to exercise against a fixed restraining force may be kept normal in size and activity is well known. Incidentally, the contracture of such muscles is of importance in stimulating a more nearly normal blood circulation through the limb as a whole.

6. Circulatory disturbances, when the limb first becomes dependent after prolonged bed rest or following the removal of a padded plaster cast, are such common phenomena that they need hardly be referred to here. Perhaps the most striking observation which will be noted by the surgeon, who has not previously used unpadded casts with early weight bearing, will be the fact that following removal of fixation the amount of swelling which takes place in the limb is rarely more than minimal, since the application of a plaster about the limb after the latter has been completely freed from interstitial fluid evidently prevents stretching of the interstitial spaces and protects the valves of veins and lymphatics from strain. At the same time stasis of blood in the capillaries and smaller vessels is rendered impossible. The necessity, therefore, for prolonged protection of the limb following removal of plaster is not necessary nor do such patients complain of discomfort during cold weather.

7. The author has upon several occasions published contributions regarding the condition which is described as acute bone atrophy and to which Sudeck's name has been applied. It is not my intention at this time to dilate upon what I believe to be the causes of the exhibition of this condition nor to discuss in detail its prevention or treatment other than to say that in our experience the most favorable treatment for the condition, when exemplified in the lower extremity, is the application of a walking cast and the resumption of active function in so far as weight bearing is concerned. The comparatively large number of cases of this extremely disabling condition, the prolongation of disability among patients who have been treated either in bed or, more especially with a dangling limb, and the almost complete absence of this complication among our own cases has convinced me that acute bone atrophy in the lower extremity is more surely avoided by the use of a technique which permits protected weight bearing during the period required for consolidation of the fracture.

The advantages of early protected weight bearing have been indicated at some length. The disadvantages are primarily two. The less important of these is that a certain amount of skill in the application of the unpadded plaster is evidently required. This, however, is not a difficult matter. The second objection is, I believe, more important. With few exceptions the patient must be admitted to the hospital and, except in the occasional case which is seen prior to the development of swelling, bed rest with suitable support and posture must be available for a few days until all interstitial fluid in the affected limb has been dissipated. I believe, moreover, that re-admission to the hospital for change of plaster when the latter wears out will in the long run prove more satisfactory and consequently desirable.

A sufficiently large number of patients have been seen who have worn the iron stirrup type of heel such as has been recommended by Boehler, and also the felt heel as recommended by me to be able to state with assurance that patients who have worn both forms of apparatus are unanimously in favor of the felt heel both as far as actual ease of locomotion is concerned and specifically with regard to the wearing of a suitable boot or other foot covering.

PRIMARY AND SECONDARY TENDON SUTURE

A Discussion of the Significance of Technique in Tendon Surgery

MICHAEL L. MASON, M.D., F.A.C.S., Chicago, Illinois

DISCUSSION of surgical technique is often considered to belong more to the art than to the science of surgery; however, in tendon repair correct technique, based upon principles derived both from experimental data and clinical observation, is imperative if we hope to secure primary undisturbed healing. We have busied ourselves a great deal with the factors and safeguards which make for complete asepsis. Dressings and other supplies are checked and rechecked; safeguards and rules provide the utmost assurance humanly possible that "sterile" and "aseptic" mean exactly that. But we have been so occupied with the bacteriological side of surgery that we have tended to neglect the technique of handling tissues. It is of course important that no bacteria be introduced into wounds, that possibly even the air in the operating room be sterilized; but it is also important that the surgeon does not kill or impair the vitality of living cells. Unless the surgeon is willing to take the time and has the patience to work slowly and carefully to develop what Bunnell has so aptly called the "atraumatic" technique, he cannot hope to secure successful results in the surgery of tendons of the hand. In few fields of surgery do minor disturbances of wound healing interfere so seriously with the end-result as in tendon repair.

Much has been said about the gentle handling of tissues but until we analyze just what we mean, we are likely to go on crushing, bruising, and devitalizing tissue without realizing that methods of handling tissues, which may yield satisfactory healing in such procedures as herniotomy or appendectomy, may prove a complete failure in the case of tendon surgery. Small bits of necrotizing tissue distal to ligatures, small hematomas and collections of serum, even an occasional stitch abscess, if these do not give rise to serious infection, may not impair the result of a herniotomy. However, such is not the case when we come to the repair of tendons. The great complexity of the tissues of the hand, the lowered temperature because of its peripheral situation, and its vulnerability to infection, coupled with the peculiarities of healing of tendon itself make this field a difficult one in which to obtain primary healing. Each step in the handling of tissue from preparation of the skin to closure and application of the dressing and splint is important and has evolved often, we must confess, rather by painful trial and error than by intelligent prescience.

The instruments and suture material are relatively simple. Few if any special instruments are required. The large tissue forceps, hemostats, and needles so commonly used, however, are too coarse for tendon repair, and heavy ligatures and sutures cannot be used. Hemostats of the mosquito or Halsted variety without teeth enable the surgeon to catch bleeding vessels accurately without grasping large amounts of surrounding tissue. Fine tissue forceps with teeth, such as Adson forceps, are excellent for handling tissues, while very fine tissue forceps without teeth are useful in picking up the delicate nerve or tendon sheaths. Senn retractors with small, narrow, smooth blades on one end and fine "cats-paw" on the other, and a second type of small ribbon retractors with somewhat broader blades, are very useful. Aneurysm needles and fine curved ligature carriers are valuable for passing tendons about bones, as are also small Reverdin needles with blunt ends. Fine bladed spatulas often serve well for retracting tendons, nerves, and blood vessels during dissection. Scissors of the manicure type enable the surgeon to cut silk ligatures close to the knot. For suture and ligature material there is no doubt in my mind as to the advantages of plain untreated silk. There is some lack of clarity, however, as to the sizes of silk which should be used in tendon repair. Much of this confusion is due to the fact that manufacturers of surgical silk do not follow a uniform system of identifying sizes. Some brands go by letters and some by numbers, and very seldom do we find any two identical. The silk should be fine, much finer than any catgut, except possibly No. 0000 or 00000 catgut. Size A Corticelli sewing silk, or even finer in this or other brands is strong enough for ligatures, for subcutaneous closure, and even for suturing tendon when little tension is expected.

From the Department of Surgery, Northwestern University Medical School and Passavant Memorial Hospital.

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When a stronger tendon suture is required, size D in Corticelli or a similar or even somewhat finer suture in one of the so called surgical silks is sufficiently strong. For very fine appositional sutures, especially for nerve suture and for appositional tendon sutures the No. 000000 black silk on straight atraumatic needles is excellent.

The needles should also be small so as to cause a minimum disruption of the tissues. Short straight Carrel arterial needles are excellent for introducing the tension sutures into the tendon. Fine round needles are occasionally valuable in tendon repair in a limited space and are used for subcutaneous closure.

For too long a time our entire concept of skin preparation has been an attempt to sterilize it by means of germicidal chemicals, and the test of the efficiency of an antiseptic agent was its ability to kill bacteria in the test tube. For a long time we quoted the values of antiseptics in phenol equivalents, disregarding its irritative action on the skin or its effect on healing afterwards. The efficacy of skin preparation is determined by taking cultures from the surface and evaluating the antiseptic according to the number of bacterial colonies which appear after its use. It appears to me that the real test of the efficacy of skin preparation is postoperative healing. No matter how carefully the skin is prepared it does not remain sterile long; we depend eventually upon the skin itself to protect the tissues from external noxious influences. Regardless of bacterial cultures we are looking for healing and not necessarily for sterility *per se*. Obviously a skin antiseptic cannot be perfect; chemical sterilization of steel is nearly impossible and it has been shown that chemical sterilization of catgut is not reliable. We should, therefore, prepare the skin in such a way that while we remove as many bacteria as possible, we still do not injure it so that it can no longer cope with organisms present.

Studies carried out by Koch on the comparative efficacy of skin preparation in clean cases, in which the nature of postoperative healing has been taken as the criterion, have shown quite definitely that there are fewer wound disturbances with soap and water preparation of the skin than following tincture of iodine, picric acid, or other commonly used agents. A similar study, made by Allen, Gibbs, and myself, of 881 "clean" appendectomies in a consecutive series of 1000 cases at Passavant Memorial Hospital, has shown that wound infection or disturbance in healing occurred 14 times or 3.00 per cent of 466 cases following iodine and alcohol preparation; 2 times or 1.03 per cent of 194 cases following picric acid; and once or 0.54 per cent of 221 cases following soap and water preparation of the skin.

TABLE I.—DISTURBANCES OF WOUND HEALING IN 881 CONSECUTIVE "CLEAN" APPENDECTOMIES

Skin preparation	No. of cases	Cases with wound disturbance	Percentage
Tincture of iodine	466	14	3.00
Picric acid	194	2	1.03
Soap and water	221	1	0.54

Table: Correlation between wound healing in 881 "clean" appendectomies in a total of 1000 consecutive cases. Included are all disturbances in wound healing: all serious and trivial infections, serous or bloody discharge of over 48 hours' duration, etc.

Obviously, when so many factors have to do with wound healing, we cannot claim that a lowered incidence of wound disturbance can be ascribed to the skin preparation alone. It is evident, however, that the use of soap and water has not been associated with an increased number of wound infections, but that, on the contrary, primary healing has taken place in over 98 per cent of patients so prepared. The absence of irritative phenomena, the natural appearance of the skin, and the reactionless postoperative healing following careful washing with soap and water are so much of a satisfaction to the surgeon that I doubt if he would give it up. It must be understood that the soap is not simply painted on the skin in the same fashion as an antiseptic. It is used in no way as an antiseptic; it is used to cleanse the skin mechanically. This manner of preparation is somewhat more time-consuming than painting with an antiseptic; it requires a full 10 minutes just as does surgical scrubbing of the hands and should be done as thoroughly and carefully. It cannot be done with a stiff brush or coarse gauze but with soft cotton. The soap should be non-irritating; the tinctures and various germicidal varieties are much inferior to the simple, white, cake soap. Except in case of emergency it is well to give the hand a preliminary washing in warm, soapy water for about 20 minutes the day before operation, to rinse the hand in warm sterile water, and to cover it with a sterile dressing. Preceding the cleansing the hand is shaved if necessary and particular attention should be paid to the nails which are cut short and cleansed with nail file and brush. Preparation of the skin in this manner provides the surgeon with a surgically clean field untraumatized by antiseptics through which he may safely perform an extensive surgical repair.

There are certain principles to be followed in making primary incisions, in enlarging wounds, or excising scars of previous procedures. In gen-

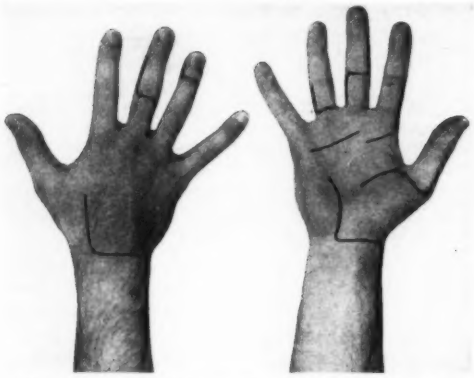


Fig. 1. Skin incisions on the hand should avoid the midline and should follow as closely as possible the lines of skin creases. They should be planned so as to produce flaps which overlie the site of nerve and tendon suture.

eral, incisions on the hand are made in such a way that the resultant scar does not contract and lead to loss of function. If possible, we must avoid scars in the midline of fingers or wrist, and scars which run at right angles to flexion creases. Incisions should be so planned that the line of tendon repair is overlaid by a flap provided with a generous amount of subcutaneous tissue and not by the line of skin suture. For example, the tendons in the carpal tunnel are exposed by a bayonet-shaped incision (Fig. 1). The palmar limb of the incision follows or is parallel to one of the longitudinal palmar creases; at the wrist it continues transversely parallel to or along a transverse carpal crease to the radial or ulnar border of the wrist. From the wrist it continues upward on the medial or lateral side of the forearm curving slightly toward the midline. If the surgeon exerts gentle traction with sponges on the skin while cutting through it, the subcutaneous vessels may be seen, grasped with fine hemostats, divided, and ligated as the incision is deepened (Fig. 2). The skin incision is carried deeply through the subcutaneous and deep fascia so that the flap is provided with a thick vascular and fatty layer of tissue, to provide both a good blood supply for the skin and a good subcutaneous covering over the underlying site of repair. While raising the flaps the skin is handled as gently as possible; it should not be crushed with hemostats or tissue forceps. With a little practice the skin can be retracted with one blade of a tissue forceps, a technical point which we have learned from Barrett Brown. It is seldom necessary to grasp the skin except occasionally during closure.

Incision on the dorsum of the wrist is similar to that on the volar surface (Fig. 1), i.e., a radial or ulnar longitudinal incision over the metacarpus, a transverse incision across the carpus, and a longitudinal continuation upward on the forearm. Exposure of tendons in the palm should be made if possible through a transverse incision in the distal part of the palm and through a longitudinal incision in the proximal part. Exposure of tendons in the fingers follows the same principles. Flaps should be made here also, and this may be accomplished by combining lateral longitudinal with transverse incisions. The guide points for the lateral incision are the ends of the transverse digital creases which insure that the incision lies well back from the volar surface. We may uncover the whole of the tendon in the finger by a single longitudinal incision, but it is better to cross the finger transversely near a flexion crease and continue the longitudinal incision along the opposite side. By combining such an incision on the finger with a transverse incision in the palm we can uncover the whole digital course of the flexor tendons and be provided with a good skin and subcutaneous flap to cover them. Exposure of the flexor tendon of the thumb is made on the same principle, as are also incisions for exposure of the extensor tendons on the dorsum of the fingers.

It is usually the case, however, that instead of elective incisions the surgeon must make compromises either with a wound already present or with a scar, and must adapt the exposure to the conditions present. The surgeon must still avoid the midline, strive to secure flaps to cover the

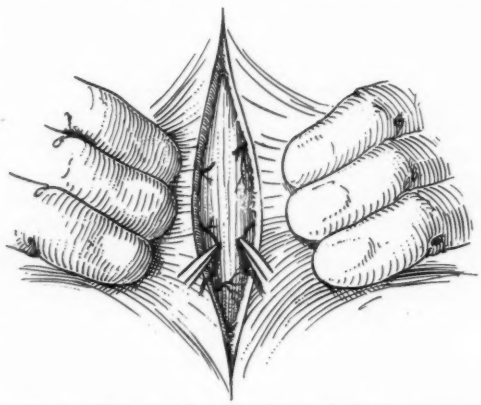


Fig. 2. While making the skin incision the surgeon exerts traction on the skin, exposing the subcutaneous vessels which are clamped, divided, and ligated.

site of operation, and provide these flaps with as much subcutaneous tissue as possible. Each situation is different and the surgeon's ingenuity often is taxed to find the best solution to the problem. A few examples will show the possibilities of such adaptation. The most frequent wounds of the fingers and wrist are transverse and are seldom of sufficient size to allow adequate exposure and repair (Fig. 3). To enlarge them, as is so frequently done, by a longitudinal incision transverse to the center of the laceration is a grievous error, since it produces a crucial wound with 4 flaps which come together in a point at the center. The tips of these flaps are difficult to oppose accurately, are poorly vascularized, and tend to become necrotic. The longitudinal line of skin closure following such a procedure directly overlies the site of tendon repair and contracts during healing.

Enlargement of an original transverse wound may be made by means of longitudinal incisions distally and proximally from either end of the original wound. If it is necessary to cross the carpus and go down into the palm, this may be done, as outlined, by a transverse incision parallel to one of the carpal creases and continued as a longitudinal incision on the hand. A transverse wound on the fingers or in the palm also may be enlarged by longitudinal incisions from one or both ends of the original wound.

In the case of scars from the original wound or following previous operations, the problem may be more complicated (Fig. 4). It may be advantageous to include the scar in the incision (Fig. 4a) and in this instance the cutaneous scar should be excised back into healthy tissues so that the resultant skin edges are soft and are provided with a good layer of subcutaneous fat. At times it may be advantageous to ignore the original scar altogether and make the exposure through

Fig. 3. .Wounds of the hand and forearm are usually transverse and may be enlarged to provide better access by incisions from either end, as indicated by dotted lines.

a b c

Fig. 4. a, A scar from a previous operation may be incorporated in the incision; b, it may be ignored and the incision may follow the line of choice; c, the scar may be excised and resutured and the incision of choice made.

the site of election (Fig. 4b). In such cases the scar will be situated on one of the flaps and will be undermined in raising the flap. Care is necessary in undermining the scar so that the surgeon does not injure adherent nerves and tendons on the one hand or leave the scar too thin on the other, thus compromising the blood supply and running the danger of necrosis. It may be wise occasionally, if the scar is very thin, to excise and suture it rather than risk its subsequent necrosis (Fig. 4c).

Careful hemostasis is necessary not only for good visualization of the operative field but also for the prevention of hematomas and oozing into the tissues after closure. Frequent sponging should be avoided, since no matter how carefully we sponge and avoid wiping the operative field, a certain amount of tissue damage is done. In the case of the hand we are able to maintain a bloodless field as long as necessary to perform even the most extensive repair. By means of a blood pressure apparatus the surgeon can control bleeding, can maintain a definite known pressure over a broad area of the arm, and can release and reapply it at will. I cannot say just how long the pressure of 250 to 260 millimeters of mercury can be maintained, but we have never found it necessary to release it until the operation has been completed. The amount of pressure necessary to control hemorrhage varies somewhat from patient to patient, but is usually 250 to 260 millimeters of mercury even in young children. The pressure is not continued without interruption for the 2 or 3 hour period of the operation. It is interrupted, however, in the interest of hemostasis rather than because we fear its continuous maintenance. During an operation under sphygmomanometer hemostasis of 250 millimeters of mercury blood vessels are visualized, venous oozing appears, and bleeding points are grasped and ligated as the operation proceeds. As soon as the dissection has been completed, i.e., as soon as tendons and nerves have been located and freed and the surgeon has outlined his plan of repair, the cuff is deflated and gauze pressure is maintained on the wound for several minutes. As soon as the cuff is released a marked active hyperemia occurs and gauze pressure must be kept up until this begins to subside, at which time the gauze is removed and bleeding vessels are grasped and ligated. After all active bleeding has been controlled the pressure cuff may be reinflated and the repair completed in a bloodless field. Since the dissection has been accomplished no more vessels are divided. Tissue oozing cannot be controlled completely by ligation and in order to prevent this oozing after closure of the wound, the blood pressure cuff should not be released until the pressure dressing has been applied. The closed wound is covered with a large amount of fluffed gauze and occasionally a sea sponge, which is bandaged on snugly. The surgeon then elevates the arm and adds further pressure with his hands and the cuff is deflated and removed. The manual pressure and elevation are maintained for a few minutes, corresponding approximately to the time of active hyperemia and the finger tips are watched to see that circulation returns promptly. When the patient is returned to his room the arm and hand are kept elevated on a pillow. In one instance following extensive dissection of an arteriovenous tumor, the hand was suspended from an overhead frame to discourage venous congestion.

There is a temptation to wrap the blood pressure cuff too snugly about the arm and compress the superficial veins so that they cannot be emptied by elevation. If this congestion occurs, the operative field will be flooded continually by venous oozing even though arterial influx is prevented. Should this complication occur the cuff must be removed entirely and reapplied since we are only wasting time by going on with the operation.

The manner of grasping and ligating bleeding vessels is an important detail. The hemostats should be small, so that they grasp only the bleeding point and not large amounts of surrounding tissues (Fig. 5). All tissue distal to the ligature becomes necrotic and must be absorbed; and if such necrotic points are multiplied many times during an operation a large amount of nonviable tissue is left in the wound. If a considerable length of vessel extends beyond the point of ligation, the excess should be removed since it also is non-viable. Ligation should be done with very fine silk and the ligature ends cut right on the knot, so as to leave a minimal amount of foreign material in the wound.

During the operation serum, blood, cellular débris, and foreign matter from the atmosphere collect within the wound. The operating room lights, even though of the so called "cold" variety, shine down on delicate exposed tissues and the moisture from the tissues is removed by the circulating air. All of these factors, débris, heat, and drying, especially during an operation lasting for several hours, are of importance and should be minimized as far as possible. They may be controlled largely by frequent irrigation of the wound with normal saline solution. The sponges used during the operation should be wrung out in salt solution, and exposed nerves and tendons

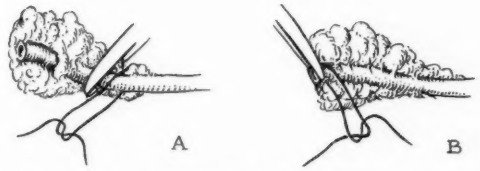


Fig. 5. Vessels to be ligated should be caught with fine forceps close to the tip as in B, ligated close to the end and the ligature cut short. In A the forceps have caught the vessel and surrounding tissues, all of which distal to the ligature are destined to become necrotic.

should be kept covered with moist sponges since they are very sensitive to heat and drying.

Closure of the wound so as to ensure prompt primary healing demands accurate apposition of the skin under a minimum of tension. It demands also a minimum of trauma to the skin edges by tissue forceps, retractors, heavy sutures, and large needles. The subcutaneous tissues should be brought together with fine silk so as to provide a soft, non-adherent bed and also to take some of the tension from the skin sutures. The skin sutures should be fine; I prefer fine to medium horse hair on fine curved cutting needles, placing first a series of interrupted sutures at 1 inch intervals and then a running suture taking bites at intervals of about 1/8 inch. It should not be necessary to exert much traction to secure accurate edge-to-edge closure.

The skin suture line should be covered with a few thicknesses of moist gauze to absorb any serum which may ooze from the wound. If the edges of a crease are allowed to come into apposition at places where the skin is folded on itself, such as occurs at the wrist or at the proximal flexion creases of the fingers, a sort of intertrigo occurs, superficial necrosis may develop, and infection take place. This complication may be prevented if the edge of a small gauze sponge is pressed into the crease so as to keep it separated (Fig. 6). Similarly the fingers should be kept slightly separated by gauze if they are to be completely covered by the dressings.

The postoperative care of the wound cannot be simply a routine, for upon this may depend the outcome of the operation. A tiny seam of skin necrosis may heal if properly cared for, but if neglected may ruin a most extensive repair. A thin skin flap may survive if pressure is correctly maintained upon it; if this is neglected, the flap may become necrotic. In such cases the flap is dressed as a free skin graft with sea-sponge pressure which is left undisturbed from 5 to 8 days. It is seldom necessary to examine the wound

Fig. 6. Dressings pressed into skin creases at the wrist and bases of the fingers, and sponges between the fingers prevent maceration.

until it is time to remove the sutures. However, I occasionally look under the dressings on the fifth postoperative day if there is reason to suspect that there has been a subcutaneous collection of serum, that an area of skin necrosis is present, or that some of the skin sutures are too tight. If a subcutaneous collection of serum has occurred, it may be possible to release it and by application of pressure prevent its reaccumulation. If a small area of skin necrosis is present it may be cleansed, the cuticle if loosened over it may be removed, a moist gauze sponge laid over it to favor drainage, and the pressure reapplied. By keeping the area clean and maintaining pressure to favor the return of circulation, the necrosis may be prevented from extending. Skin sutures in the palm are best left undisturbed for 12 to 14 days since healing of the thick palmar skin is quite slow. It is my usual practice to cut the continuous suture in a number of places about the tenth postoperative day, remove it about the

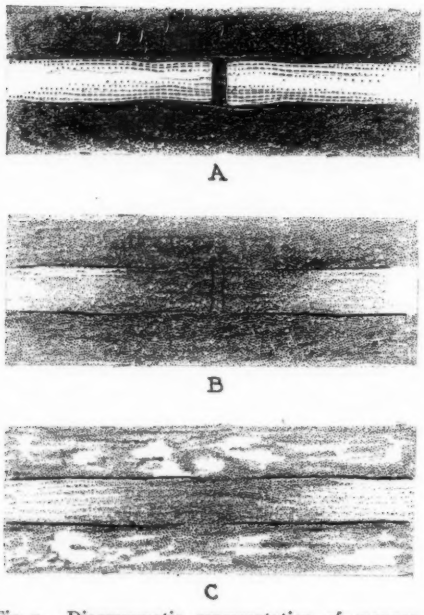


Fig. 7. Diagrammatic representation of manner of healing of tendon. A, First week; proliferation of peritendinous and intratendinous connective tissues. B, Second week; tendon cell proliferation and obliteration of gap. C, Third to fourth week; consolidation of gap tissues and beginning stages in adaptation of surrounding tissues to subserve gliding function.

twelfth day, and remove the interrupted sutures on the fourteenth day. But there is no routine about it. If at any time a suture seems too tight it is cut, although it is not necessarily removed.

Such in brief are some of the general principles of operative technique applicable to all types of surgery, but a *sine qua non* for successful tendon repair. There are, however, certain peculiarities of tendon which must be taken into consideration. Its long parallel bundles of collagenous fibers have tremendous strength but fray and separate if the tendon is pinched or squeezed and ordinary sutures pull out easily. The blood supply of the tendon is relatively scanty, its longitudinal vessels are scarcely enough to care for its ordinary needs, and they tend to diminish with advancing age. Vessels entering by way of mesotenon or paratenon may be very plentiful in such places as the wrist or dorsum of the hand but are quite scanty in such places as the volar surface of the fingers. The sutured tendon is always under some tonic pull from the muscle above so that even when immobilized on a splint absolute quiet cannot be obtained, nor can we be certain that even if we could secure absolute quiet it would be advisable to suppress muscle tonicity entirely following tendon repair.

The manner in which tendon heals gives us some clew to the principles of repair (Fig. 7). When divided tendon ends have been united by suture, reparative processes start within the first 24 hours. They begin in the intra- and peritendinous connective tissues which proliferate across the site of union and into the gap between united tendon stumps. Not until the fourth or fifth day is there evidence of actual increase in the number of tendon cells; the union which exists at this time and the effective union for the first 10 to 14 days is provided for by the thickened and proliferated connective tissue elements. By the end of the second week the gap is bridged by proliferated tendon and from then on the surrounding tissues tend to revert to their original function of serving as a gliding mechanism. During the early stages of repair the tendon must become attached to the surrounding tissues. If these early vascular attachments are derived from dense fibrous or bony tissue, firm adhesions are almost certain to form and the tendon becomes frozen in its course. If the attachments are derived from fatty or areolar tissue, they tend to loosen slowly and eventually permit free motion. Tendons surrounded by synovial sheaths receive blood supply through thin mesotenons and are partly or entirely surrounded by dense bony and fibrous tissue or osteofibrous tunnels. The flexor tendons in the fingers represent this type and, as is well known, offer the poorest prognosis of

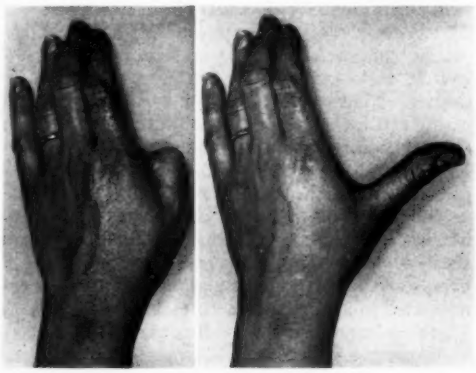


Fig. 8. Division of extensor pollicis longus near base of proximal phalanx. Patient first seen 3 days after injury; too late to suture. Thumb splinted in extension for 5 weeks with complete healing and functional return.

all the tendons on the hand following repair. The other group of tendons are those surrounded by paratenon, i.e., by lax, areolar tissue from which fibers and blood vessels run directly into the tendon. The extensor tendons on the dorsum of the fingers and distal half of the metacarpus belong to this group. The paratenon covered tendons are well supplied with blood, run through areolar tissue which limits retraction, and present an excellent prognosis after repair. In fact it has been our observation that the dorsal tendons often heal spontaneously if properly splinted (Fig. 8).

The sheath covered tendons on both the volar and dorsal surfaces of the wrist have good mesotenons, with the possible exception of the extensor pollicis longus, and with the exception of their short course through the carpal tunnel are surrounded on all sides by loose areolar tissue. Such tendons heal well after proper repair and with a minimum of adhesions. Within the carpal tunnel itself the flexor tendons are confined within a narrow osteofibrous channel and dense adhesions are likely to occur unless some measures are taken to insure that at least along part of the circumference of the tendons there is fatty or areolar tissues.

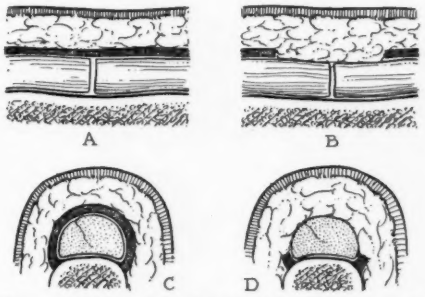


Fig. 9. Excision of window in fibrous digital sheath to provide subcutaneous fatty bed for healing tendon. A, Longitudinal, and C, cross sections of finger before excision show line of suture entirely surrounded by osteofibrous tissue to which the healing tendon becomes firmly united. B and D, Corresponding sections following excision of fibrous sheath. The healing tendon; over three-fourths of its circumference is in contact with fatty areolar tissue.

The flexor tendons on the volar surfaces of the fingers present a difficult problem of repair. There

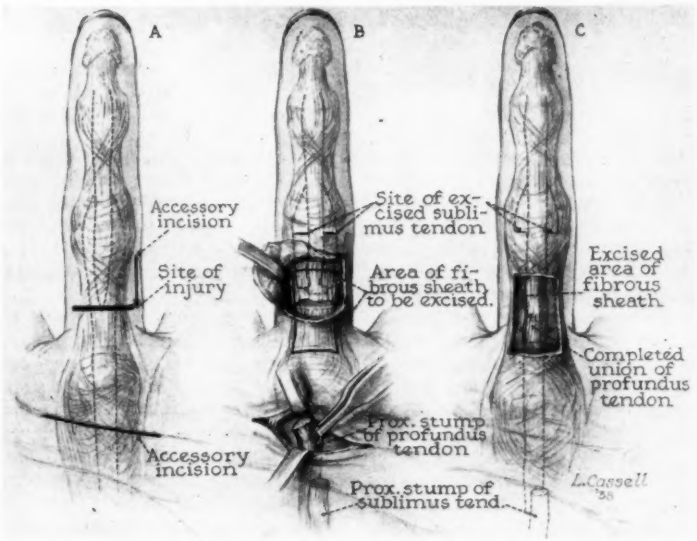
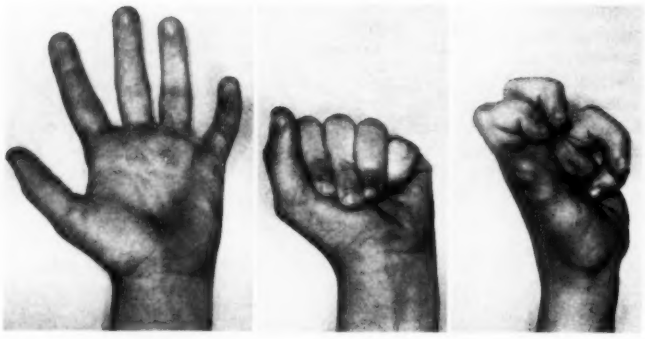


Fig. 10. Method of repair of flexor tendons when divided in the digital sheath. A, Short accessory incisions permit exposure of divided tendon in finger and palm. B, The proximal stump of the sublimis tendon is shortened and allowed to retract, or is fastened by side-to-side suture to the profundus tendon. The distal stump of the sublimis tendon is excised well distal to proposed line of tendon suture. C, After suture of the flexor digitorum profundus tendon, a window about ½ inch long is excised from the fibrous sheath over the site of repair. When the skin is closed the fatty subcutaneous tissues close over the area of suture.

a b



c

Fig. 11. J. S., age 6, Passavant Hospital No. 36237, April, 1938. Cut with broken glass at base of left ring finger; division of both flexor tendons and one digital nerve. Primary suture within 2 hours after injury by method shown in Figure 10; a, at time of admission; b, 3 weeks after repair at time of removal of splint; c, 3 months after injury.

are in reality 3 tendons, the profundus and the 2 slips of the sublimis, tightly enclosed in a dense canal. On the deep surface of the tendons are the periosteum of the phalanges and the dense capsules of the interphalangeal joints, while on the lateral and volar surfaces of the tendons is the tough fibrous tendon sheath (Fig. 9). The sheath is just large enough for its contents and provides scarcely enough space for the repair of one tendon. The line of tendon suture becomes adherent to the walls of the tunnel and function is greatly reduced if not entirely obliterated. All surgeons are agreed that the profundus only should be repaired and the frequently meager success of primary suture has led many surgeons to advise against it and to advocate secondary repair by a graft in all cases. It has seemed to me that repair should be possible if we could insure a fatty bed for the healing tendon and in several recent cases of primary repair the following procedure was carried out (Fig. 10): The sublimis stumps were excised distally and proximally and the profundus sutured in the usual manner. The fibrous sheath was then excised over the area of repair for a distance of about ¼ inch above and below the suture line so that when the wound was closed the united tendon lay directly against fatty subcutaneous tissue. In the few instances of immediate repair in which this procedure has been carried out a successful result has been obtained (Fig. 11).

There are numerous methods of tendon suture and each is enthusiastically recommended by its proposer. We have tried a number of methods, choosing those which have seemed to meet the requirements of ideal suture: namely, that it has a firm anchorage in the tendon, produces a minimum of disruption, does not burden the tissues with a great amount of suture material, leaves the opposed tendon ends free of suture material, and, lastly, does not leave knots between the stumps. During the past year we have been using a method of suture which Dr. Harvey S. Allen and myself have tested out experimentally (Fig. 12). It meets the requirements here enumerated and has proved satisfactory both experimentally and clinically. No. 6 or 8 twisted silk (tensile strength 4½ to 6 pounds) is used on straight

arterial needles. A small bundle of peripheral tendon fibers is caught about 1 centimeter above the tendon end and the suture is knotted about it. The suture is then passed straight through the tendon to come out on the opposite side at a level about ½ millimeter higher than the level of the knot. A second length of suture material is tied about a small bundle of peripheral tendon fibers just below the point of emergence of the first suture, and is then passed through the tendon so as to come out on the opposite side directly above the knot of the first suture. The long ends left at the knot on either side are then cut short and the other ends given a slight pull so as to be sure they are firm. Similar sutures are placed in the opposite stump and the tendons approximated by tying the corresponding sutures. After the tension sutures have been tied the tendon ends may be accurately apposed by a few sutures of No. 000000 nerve silk. The mechanism of attachment of this suture is quite simple; each half of the suture pulls straight across the tendon and is prevented from slipping by the knot of the other suture over which it rides. The line of pull is thus transferred from a longitudinal to a transverse direction so as to run at right angles to the tendon instead of parallel to its fibers. It does not encircle or constrict the tendon, but simply produces an indentation at one point on either side. The blood supply of the halves of the tendon lying to either side of the transverse course of the suture is not disturbed. The opposed ends are free of suture and there is no foreign material between them.

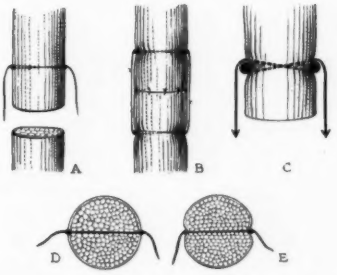


Fig. 12. Method of tendon suture in which the longitudinal pull of the sutures is converted into a transverse pull across the center of the tendon.

When confronted with a recent tendon injury, the surgeon must decide whether or not to perform primary repair. There is no question as to the more favorable prognosis of primary repair of divided tendons. There is also no question as to the poor prognosis of secondary repair following failure of a primary one. If the surgeon, therefore, is not reasonably certain that primary repair can be accomplished, it is much better judgment simply to close the wound and plan on secondary repair in a clean wound. The decision to perform primary suture must be made on a consideration of several factors. It is usually unwise to attempt primary repair of tendons if the wound is over 3 or 4 hours old when first seen. In case of flexor tendons on the fingers probably not over 2 hours should have elapsed. If this limit has been passed and if the limit of 6 or 8 hours has not been passed, the wound may be cleansed and closed but the tendons should not be sutured.

The possible sources of wound contamination should be taken into account. We fear especially contamination with bacteria from human sources, and if we have reason to believe that such organisms have gained entrance into the wound it is unwise to undertake tendon suture. Curiously enough human acclimatized bacteria seldom gain entrance at the time of injury; the usual open wound seldom harbors them. The human bite wound, injuries with postmortem or operating room scalpels, and pins used on septic cases are the only such wounds at all commonly encountered. However, such bacteria may gain entrance as secondary invaders after the injury and every effort should be made to search out such possible sources. Careless first aid treatment, emergency dressings with soiled linen, handkerchiefs, and towels, careless probing with fingers or unsterile instruments, hasty ligation of bleeding vessels under questionable asepsis, and droplet contamination must be considered. It is unwise to attempt primary repair if incomplete surgery has been done elsewhere even though the patient is seen well within the time limit. One unfortunate experience has forced me to defer tendon repair if an antiseptic has been poured into the wound at the time of first aid. Lastly, the surgeon should have at his disposal the assistance and equipment to carry out the operation. To attempt delicate tendon repair with the large forceps and sutures which form the only equipment of many operating rooms is not only useless but may rob the patient of the only chance of obtaining a functioning result.

However, if the various conditions briefly outlined can be met, primary repair of divided tendons is indicated. It is my conviction that almost any wound may be carefully cleansed and rendered surgically clean provided it is seen early and is not contaminated with human acclimated bacteria. I do not desire, at this time, to discuss the general principles of the management of open

wounds, which have been the subject of several recent papers by Reid, Koch, and others. Primary tendon suture is postulated on initial care such as these men have outlined. It must be understood of course that in some cases the removal of devitalized tissue, the need for obtaining skin covering, or other complications of the open injury may preclude primary tendon repair. However, in the absence of such complications and if the other prerequisites are present, primary tendon suture may be safely undertaken.

The propitious time to perform secondary repair will depend mainly upon 2 factors: the condition of the tissues of the hand and the manner of healing which followed repair of the original injury. If the wound was closed and if it healed by primary intention, tendon suture may be safely undertaken 3 to 4 weeks later. If, however, there was a mild inflammatory reaction or a simple staphylococcic infection, we should wait 6 to 8 months after the infection has subsided and the wound has completely healed. If a severe spreading infection was present, particularly if streptococcal in nature, an interval of 12 to 18 months should elapse between the cessation of the reaction and the time of secondary repair. There are no infallible tests to indicate whether or not the tissues are free of bacteria, and it is only by experience that we have arrived at these time intervals. In a few cases some lesser procedure such as division of the collateral ligaments of the metacarpophalangeal joints has been done as the first step in repair and this has served as a test of operability.

The conditions of the tissues must also affect the decision as to time of secondary suture. We must certainly wait until the induration has subsided and the skin and subcutaneous tissues are free and soft. The joints moved by the severed tendons should be freely movable since it is useless to repair tendons if the fingers are stiff. It not infrequently happens that several weeks or even months of physical therapy may be required to get the tissues into a proper condition to permit operation. In some instances it may be necessary to mobilize joints operatively, particularly the metacarpophalangeal joints in which case division of the collateral ligaments is often successful. In some instances dense adherent scars must be excised and pedicled flaps placed over the area so that subsequent tendon repair may be accomplished through loose fatty tissue. Secondary tendon repair often requires a considerable amount of planning, and the surgeon who undertakes it should try to visualize the various procedures and their probable sequence. He should, however, realize that he is not dealing with stereotyped procedures, that he should be ready to meet conditions as they present themselves at the operating table, and he will often be required to make his final decisions as to procedures only after the dissection has been completed.

SUMMARY

Successful tendon repair on the hand, whether it be primary or secondary, will depend upon attention to many apparently trivial details. The surgeon should strive as hard to master an atraumatic technique as he does to ensure asepsis. The atraumatic technique must be followed from the time the skin is prepared for operation until the patient is finally discharged from care. During operation the greatest pains should be taken to prevent tissue injury, either mechanical or chemical; to ensure hemostasis, and to avoid tissue devitalization. Special attention should be given to details of dressing the wound and to postoperative care. Tendon suture itself is based upon a knowledge of the manner of tendon healing and a method of suture has been described. Primary repair is always advisable if the surgeon can secure the wound early enough, and can assure himself that contaminants from human sources have not entered the wound. Secondary repair may be undertaken when the surgeon is confident that the wound is free of bacterial contaminants and the tissues of the hand have regained normal consistency.

RECONSTRUCTIONS IN NON-UNITED FEMORAL NECK FRACTURES

OTTO J. HERMANN, M.D., F.A.C.S., Boston, Massachusetts

NON-UNION of intracapsular fractures of the femoral neck still occurs. A good many of such patients get along quite well with painless fibrous union —one good authority rated such cases in his clinic as 75 per cent—but the remainder do not function at all or function with crippling pain. These non-unions present problems for solution. There are also patients who have union but who are invalid cripples because of pain on weight-bearing or even at rest. This pain is due to a complicating arthritis or to a process of disintegration taking place in the femoral head following internal fixation by nailing or by other forms of metal fixation.

It is obvious that some type of constructive or destructive operation is necessary to give these patients painless and functioning hips. It is evident, however, that because of local or general contra-indications some of these unfortunates cannot be operated upon and must finish their lives as best they can, with crutches, ambulatory splints, pelvic belts, or even wheel-chairs, or in bed. The fair and good surgical risks can be given relief and a varying degree of restoration of function by some type of reconstructive hip operation.

From our personal limited experience with hip reconstruction we believe that there is no universal method. We agree with Brackett, one of the great pioneers in this field, who stated in a recent discussion on this topic in referring to the operating surgeon, that "The important factor is his choice of procedure." To select as best we can, we have learned that we should and must have detailed and intimate experience with and knowledge about the various accepted methods of hip reconstruction before we attempt to do any work in this field.

When we analyze present day methods we find that, in the main, they are surgically old and tried, with some excellent modifications and, naturally, designated with new names. The original Whitman, Brackett, Lorenz bifurcation operation and even the hole-drilling principle in the treatment of non-united fractures first promulgated by Daniel Brainerd in the fifties of the past century, are the forerunners of the modifications by Colonna, Magnuson, McMurray, Shantz, and Bozsan's hole-drilling operation in non-united hip joint fractures. We have found these latter procedures, which we shall endeavor to evaluate from various angles, plus the hip fusion operation to be sound.

The Colonna type of reconstruction. This consists in (1) the sectioning close to their insertions of all the muscles attached to the region of the greater trochanter with preservation of a thin fibromuscular tissue over the upper end of the bone; (2) the removal of the head; (3) the placing of the upper extremity of the femur deeply and firmly within the acetabulum and the transplanting of the gluteus medius and minimus group of muscles downward on the shaft of the femur as far as they will reach, and the secure fastening of them to the bone; (4) after wound repair and dressing, the application of a plaster-of-Paris spica with the leg in about 20 to 30 degrees of abduction; (5) at the end of 4 weeks the cutting away of the lower posterior half of the cast in the affected leg so as to allow knee flexion several times a day; (6) the removal of the entire cast in the sixth week and the placing of the leg in a special type of foot sling hitched to a Balkan frame and the institution of a special series of exercises; and (7) the use of crutches at the eighth week and direct weight bearing 1 to 2 weeks or more later, depending on the individual case.

The Magnuson method (modification of the Brackett method). We believe with Magnuson that this method combines the best features of the Brackett and Whitman operations. The essentials of this procedure are: (1) The exposure by the Smith-Petersen approach; recently we have adopted the Callahan approach; (2) the removal of fibrous tissues between the fractured ends and then a test made to ascertain whether the head is viable or non-viable; (3) the hollowing of the head in the form of a cone, pointing upward and slightly backward; (4) the rotation of the femur inward, and with a thin-bladed chisel the removal of the trochanter in a line sloping from the base of the neck of the shaft; (5) the rounding of the end of the shaft in the same curve as that in which the head has been hollowed out; (6) the abduction of the leg so that the upper end of the shaft may be

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pried into the head; (7) the reattachment of the trochanter to the shaft on the cut surface so that it is moved downward and outward and held in that position by heavy silk ligature; (8) the application of a plaster-of-Paris spica which is retained for 8 to 12 weeks, and occasionally longer as we have experienced; (9) the removal of spica, but the legs are kept in some abduction; (10) finally, periodic clinical examinations and check-up roentgenograms to determine when actual direct weight bearing can be started.

The various direct bone grafting, pegging, and hole-drilling methods. These we believe need not be described since they are so varied. Suffice it to say that when we decide to use such a procedure we combine them—the direct inlay graft together with bone chips, as well as hole-drilling. Such operations are followed by the use of plaster-of-Paris spica fixations for 10 to 14 weeks and then the use of crutches and protective ambulatory splints until definite firm union has been established.

The McMurray osteotomy. This is a bifurcation operation based on the suggestion of Lorenz in which the shaft of the femur is transferred directly under the lower margin of the acetabulum and head of the femur. The chief purpose of this operation is to change a shearing force into a direct one. The following are the steps in this operation: (1) A 6 inch incision is made along the lateral side of the upper end of the femur in the trochanteric area. (2) The fracture site is exposed so as to place the osteotomy line accurately. (3) An oblique osteotomy is performed beginning on the outer side of the shaft, generally about the lower end of the greater trochanter and ending above the tip of the lesser trochanter. (4) The upper end of the shaft of the femur is pried and shoved inward until the cut end is under the acetabulum and femoral head. This is followed by repair of the wound. (5) A plaster-of-Paris fixation is used for a period long enough to ensure union at the site of the osteotomy. This fixation of the limb is in the neutral position in very slight abduction in order to prevent the development of knock-knee following removal of the plaster cast. Fixation is maintained generally 3½ to 4 months. The knee is kept in slight flexion so that the degree of rigidity is decreased.

The hip fusion method. This we have done generally by means of Hibbs' method or with some modification when the head had to be removed or was useless. In these cases our former chief, Dr. Cotton, combined Hibbs' fusion operation with Albee's old plan of squaring. Following the fusion, a plaster-of-Paris spica is applied and retained until fusion is established. As a rule, this takes 12 to 16 weeks. Then a walking spica is applied or if fusion is quite firm a protective ambulatory splint and crutches, or simply crutches are used. No direct weight bearing is permitted until union has been firmly established clinically and roentgenographically.

These then are the reconstructive operations for non-union of femoral neck fractures which we have used in the course of the past decade, and the following is an evaluation of each method based on our own experiences:

The Colonna method (10 cases). The patient must be a good operative risk for this procedure. The chronological age need not be a deterring factor. The patient must, in the surgeon's judgment, be able to withstand a good amount of surgical trauma. The fracture site should show definite absorption of the femoral neck or head; the less femoral neck remaining, the easier the operation and the better the result. This method can also be considered in cases in which the head of the femur is dead. Arthritic changes in the hip are not conducive to a good result with this type of reconstruction and therefore rule out this operation.

The following is what we have found in 7 successful Colonna cases: The bed and hospital confinement was shorter than by any of the other methods we have used. The average was 6 weeks in bed with another 2 weeks up and about the ward before discharge. Patients left the hospital under their own power with the aid of a crutch or cane depending on their confidence and readjustment ability. The average shortening in these cases was a scant inch; 3 had ¾ of an inch, 3 had 1 inch, and 1 had 1½ inches of shortening. We found this shortening to be of no material consequence. It could be corrected with a slightly raised heel. Internal and external rotations at the hip were quite limited; abduction ranged from 25 to 45 degrees, adduction from 20 to 25 degrees. The flexion at the hip was good and extension normal. Patients could stand alone on either leg. They had painless hips and could walk ordinary distances without fatigue or discomfort though with a slight limp. They had, however, some social and physical discomforts. They complained of inability to put stocking and shoe on the affected leg, and protracted sitting, as at card table, movies, etc., caused a sense of stiffening and discomfort in the affected hip.

To arrive at this result the patient must go through a fair amount of severe surgical trauma; but the period of hip and leg fixation is comparatively short as are bed confinement and hospitalization, which are important items when we know

as in other procedures, what prolonged fixation and bed treatment will do to a patient locally and generally. It is also an important factor from an economical standpoint which today is the concern of both patient and hospital.

The 3 unsuccessful cases were the following:

CASE 1. This was a poor choice. Before operation the patient showed some degenerative changes (not absorption) and following operation these changes progressed. However, final fusion set in and today the patient has a stiff and fairly comfortable walking hip. She has to use a cane and can walk quite well.

CASE 2. This case we do not know exactly how to classify. It was a real problem. The patient had a severely painful, non-united femoral neck fracture of the left leg (even on lying down) with an already fused knee joint on the affected leg, and 2 fused elbow joints all due to an old infectious arthritis. After some observation and persistent pleading on the patient's part, a Colonna operation was decided upon in order to give her at least a somewhat mobile joint with the hope that it would not fuse later. The operation was performed. The hospitalization in this case was very long for a Colonna case—16 weeks. This was due chiefly to the difficulty the patient had in readjusting herself and getting confidence in going about on crutches. However, despite her general arthritic condition she did finally succeed in getting around. The following is a copy of our brief notations in this case in the 1 year follow-up examination:

"Patient still uses crutches. This is because of left knee. painful right knee, and hip. She can sit with comfort in chairs but needs help to get up. She prefers sitting on arms of lounging chairs because of comfort and ability to get up under own power. The left hip (the Colonna hip) is painless. Has only occasional soreness in it. Can put weight on left leg without having pain. Rotation limited. Flexion and extension at hip are good, free, and painless through limited range. Patient finds she has to bear most of her weight through the crutches on left leg because of pain in her right knee and hip."

CASE 3. This was an instance of failure due to subluxation of the upper end of the femoral shaft after operation; subsequent attempts at replacement were only fair. Convalescence was protracted; hospitalization lasted 5 months and the patient was on crutches for 9 months. This case is now coming through fairly well and for a curious reason. Check-up roentgenograms have shown ossification in the capsule and 18 months after operation the patient could get about with a cane on a painless hip. Nature has fashioned an excellent shelf for the femur.

This case taught us the great importance of snugging the upper end of the femoral shaft into the acetabulum and seeing that it is kept there while wound repair, dressing, and spica fixation are going on. We have found that the leg should be kept in at least a 20 to 25 degree abduction spica fixation. It also proved to us the importance of utilizing the capsule in the later wound repair.

The Magnuson operation (*5 cases*). As previously mentioned, this procedure combines the best features of the Whitman and Brackett operations. It should not be considered in cases complicated by arthritic changes, or by any suspicion of cartilage degeneration, irregularity, or in cases in which the head of the femur is dead. We are also of the opinion that non-united fractures of over 1 year's duration, or having no femoral neck left are also poor risks for this operation. From our 3 successful cases by this method we collected the following data:

The method required a very careful selection of cases. It involved somewhat more surgical trauma than the Colonna method. The fixation of the hip and leg and the bed confinement were quite long—10 to 16 weeks. The patient left the hospital from the end of the tenth or twelfth to the eighteenth week. He left under his own power using crutches or an ambulatory Thomas splint and cane. He was bearing direct weight on the affected hip from the sixth to the ninth month. At that time the patient had a solid union of the reconstructed neck and head. He had a hip joint that was 90 per cent and more normal; it was as nearly normal as one could expect from a reconstruction.

The 2 poor results were and are unfortunate. Neither fracture united. There was absorption at the reconstructed site soon following the operation. Both patients were over 60 years of age, chronologically and physically. The non-united fractures were of 12 and 16 months' duration. One of these patients has since died and the other is up and about as a crutch invalid but has a painless hip.

These were the cases which caused us, when considering the Magnuson method, to avoid non-united fractures of over 12 months' duration and in elderly people. Two of our successful cases were also benefited by these failures in that we not only chose them more carefully but in addition to the reconstruction we did the Bozsan's hole-drilling and crammed in some bone chips at the reconstruction site.

Bone grafting and allied methods (*3 cases*). The selection of non-united hip fracture cases for bone grafting, bone chips, and hole-drilling, we believe, must be made early and with due care to the general condition of the patients. They must be above average physically in order to withstand successfully the prolonged spica and bed confinement. The femoral heads should be in good condition and some of the neck should remain. Here again, those patients with arthritic changes or tendencies, or with any joint irregularity, should not be selected for these procedures.

Our comments on our 3 successful cases are as follows:

The non-united fractures were of 6½ to 8 months' duration. The femoral heads were all in good condition and a fair amount of femoral neck

remained. On one we did a simple, thorough cleaning out of the fibrous tissue between the head and neck, and crammed the resulting gap with bone chips. The 2 others had not only the hole-drilling, as advocated by Bozsan, but also inlay grafts and bone chips. In these cases spica fixation was maintained from 12 to 16 weeks and hospitalization lasted 14 to 18 weeks. All these patients left the hospital wearing protective ambulatory splints and using either one crutch or a cane. Direct weight bearing averaged from 6 to 8 months. The knee joints in the affected leg in 2 of these patients lengthened the convalescence and delayed return to normalcy. The third patient had limited knee motion at operation and this limitation persisted. The hips in 3 patients had practically normal range of function which was better than in the successful Magnuson cases.

The simplicity, ease, and non-shocking quality of these allied methods impressed us markedly and made us aware that early recognition of non-union and early decision as regards stimulating therapy should and must be sought.

The osteotomy procedure (2 cases). As in the preceding methods, arthritis and other degenerative joint changes rule out this operation. We have not much to say here since it is only during the past year that we have used this method in our non-union hip therapy. We followed the McMurray technique. This method was chosen for only 2 patients because they were deemed poor risks for the prolonged and severe surgery of other methods. We can say that the simplicity of the osteotomy, etc., appeals to us. Moreover, if, as McMurray, Schantz, and Schumm report, the successful end-results, which are of a goodly percentage, give a high degree of painless hip function which is nearly normal in many cases, this method may supplant those requiring more severe and destructive surgery to accomplish their ends. We cannot give an opinion on this for we have practically no experience with the method. The only 2 patients we had died sometime following the operations. The one feature we do not like about this procedure is that the period of fixation and hospitalization is too prolonged for such poor surgical risks although they do possess a good chance to survive the operative procedure itself.

The hip fusion operation (3 cases). To date we have used this fusion method in only those non-united cases in which definite arthritic or other joint changes are shown. Again, our experience is limited but it has been most satisfactory. Successful end-results were obtained in 2 and in a third patient successful outcome followed a secondary stimulation.

Of course, the successful end-result is a stiff hip with the social and physical discomforts very similar to those after a good Colonna end-result. At least, that is how we have viewed it. To attain this result, however, the patient does have to go through severe surgery, a protracted spica fixation and hospitalization, varying in our hands from 12 to 16 weeks. These are serious factors which we must face before selecting such a procedure which is so tempting because the percentage of failures following its use is lower than for any of the other present day methods.

This then is the evaluation of our experience with the reconstruction methods for use in non-united femoral neck fractures. It is true the number of cases is apparently small for almost a decade of work. Unfortunately, this is not due to the scarcity of non-united fractures; it is due to the difficult task of selling an operation to such poor cripples, who already have had their share of fixation and hospitalization, and to the selection of the cases. In our whole series we had but 2 deaths. The comparatively low mortality in these cases in which the surgery often is devastating is due probably to the careful pre-operative preparation, the well selected and conducted anesthesia, and to the postoperative care.

The percentage of successful end-results is quite discouraging. We have been tempted to adopt hip fusion as our routine method for it offers the highest percentage of so called good end-results, and also because of the fact that occasionally progressive postoperative changes in a hip operated upon by another method may convert an apparently good end-result into a poor one. As Colonna has stated somewhere, we would be sacrificing the convenience of motion to the greater strength and more practical use of painless weight bearing. A universal "stiff hip" idea, however, does not and should not satisfy us. We must and should keep on endeavoring to select the operation for the individual—the operation which will result in that type of hip function which that particular patient needs. But if there are intra-articular or extra-articular contra-indications for that procedure, we should select the one which will insure a stable, painless hip. It should be stated that there will be times when the surgeon finds, on actual visualization of the hip joint, conditions other than he expected. He must be ready to discard any preconceived plan of procedure and adopt one that is better adapted to the actual local conditions, thus ensuring a better end-result.

The good results we had in our cases make us wish that earlier recognition and immediate appropriate treatment could be made. This is a job for

the pathologist, the surgeon, and the roentgenologist. Dr. Ferguson, of New York, has done some excellent roentgenographic work in the diagnosis of pre-coxa-plana cases. Why could not someone do the same with non-united hip fracture cases? If early diagnosis of non-union, i. e., in the first 4 or 5 months, could be made, we are sure that some immediate, appropriate, stimulating treatment of a simple nature would be all that would be required. It would no doubt give the patient a practical normal hip and would obviate, in the great majority of cases, the need of any type of hip reconstruction as is the case when the hip fracture is allowed to go to frank non-union.

In conclusion I would once more refer to Brackett who said: "There is now need of special study and observation particularly by collection of end-results to aid in the application of the methods which we already have to the various types of cases and to act as a guide in the choice of the method of treatment."

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THE TRACTION TREATMENT OF FRACTURES OF THE OS CALCIS

JOHN DUNLOP, M.D., F.A.C.S., Pasadena, California

THE value of traction treatment unquestionably means whether a satisfactory reduction may be accomplished, whether it is a better method of reduction than a purely manipulative one, and also, whether the results are more satisfactory than when an arthrodesis is performed.

Many methods of reduction with the use of traction have been devised, some of them very recently, but the outstanding method, and the one on which many of the newer suggestions are based, is without doubt that of Lorenz Boehler, a description of which was first published approximately 10 years ago. In brief, it consists of breaking up the impaction as thoroughly as possible, and then with a system of fixed traction, drawing the fragments into as nearly a normal position as possible. When this is accomplished, as proved by roentgenograms, the fragments are pressed together laterally to overcome their spread and to accomplish impaction in this replaced position. At first, traction was continued after fixation of this remolded mass in a plaster cast, but later Boehler discontinued the traction after fixation, and allowed all the pins to remain for extra fixation. The after treatment consists of plaster fixation until bony union has taken place, and walking is encouraged as early as possible with the use of a walking iron attached to the plaster. This he termed "the walking cast" and its main object is to maintain the proper muscle tone and to enhance circulation.

Previous to Boehler's suggestions as to treatment, little had been done since Cotton recommended the breaking up of the impaction and reimpacting the fragments, especially the troublesome mass protruding below the external malleolus which was thought to be the most disabling feature. So anxious were surgeons to find a possible solution for this seriously disabling injury that Boehler's method became popular almost over night. Boehler's paper gave a very detailed technique for every step in his procedure, and it seemed that at last a way to restore these injured men to their former usefulness was at hand.

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The method was widely if not wisely used. Seemingly it was employed without a very clear understanding of the real significance of the problem at hand, and the end-results of the average cases so handled showed very little improvement in the amount of permanent disability.

This condition led to a very considerable amount of real investigation as to why this seemingly accurate method of reduction failed to give the expected and hoped for results, and from this has come a much clearer conception of the injury and many suggestions as to how the problems may be solved.

Boehler, in his early papers, formulated a classification of the types of fractures. He classified them according to the portion of the bone affected by the fracture, the deformity resulting from the involvement of certain areas, just how each problem was to be handled, and its possibility of correction.

It was probably because of excessive enthusiasm that the profession did not take in fully the many problems connected with this method and so were not prepared to handle the many pitfalls encountered. Much of this work was unquestionably done without a full realization of its magnitude. As a result, there has been a tendency to develop other methods rather than to determine and correct the weaknesses found in Boehler's procedure. From all this uncertainty much good has come and will continue to come as our statistics of end-results become more accurate and helpful.

In a broad way, for the sake of study of the use of traction in reduction, we must classify the fractures lending themselves to such a treatment into 2 main groups: Those not entering the joints of the os calcis, and those which do enter the joints, more especially which enter the subastragalar joints.

The superior surface of the os calcis contains 2 distinct facets or articulating surfaces, which have an important bearing on comminuted fractures of the body of the bone, as will be shown later.

Fractures of the posterior portion of the os calcis, that is, that portion of the body posterior to the subastragalar joint, and spoken of as the

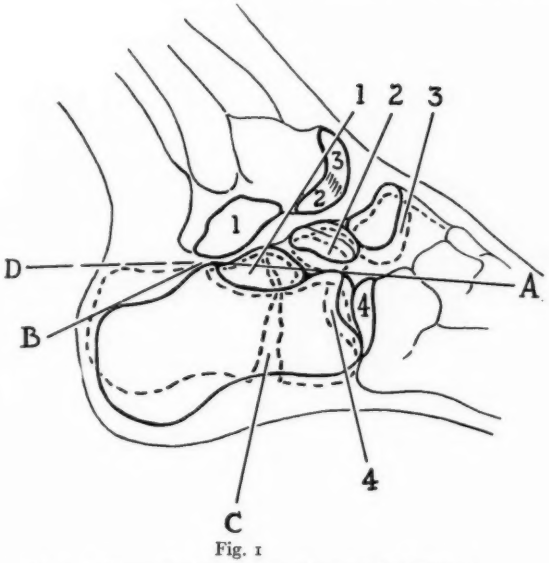

Fig. 1

Fig. 1. A diagnostic sketch of the subastragalar joint and the midtarsal joints. The unbroken outlines of the facets marked *1*, *2*, *3*, and *4* show the joints opened from the lateral side and plantar flexion of the forefoot. The dotted lines of the misplaced bones and facets following fracture show the change in relation to the facets, which is the chief factor in producing a stiff and painful subastragaloid joint. The basis for this sketch was taken from Conn's article, "Fractures of the Os Calcis," in *The Journal of Bone and Joint Surgery*, April, 1935.

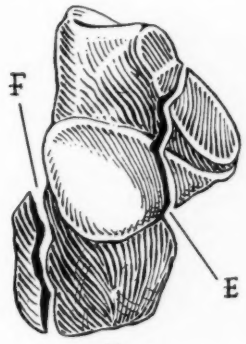

Fig. 2

Fig. 2. A schematic drawing showing 2 common types of longitudinal fracture. The fracture marked *E* is a separation of the sustentaculum tali with rotation of the main portion of the os calcis. It is this rotation and separation which destroys the normal relation of the articulating facets and produces pain and reduced function of the subastragalar joint. The fracture marked *F* demonstrates a longitudinal fracture of the tuberosity not entering the joint, and is a frequent cause of bone pressure with accompanying pain below the lateral malleolus.

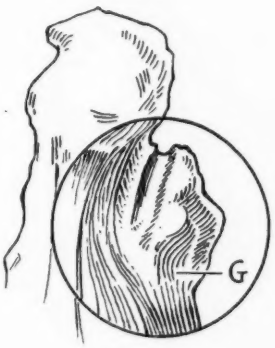

Fig. 3

Fig. 3. The under surface of the sustentaculum tali. The calcaneoscaphoid ligament marked *G* when disrupted from its normal course as a result of fractures of the sustentaculum is a frequent cause of pain in the midtarsal joint.

tuberosity, as a rule are the more simple types to deal with. They may be split fractures, where the fracture line extends longitudinally through the bone from the back forward, or they may pass directly across the bony mass. They may become impacted and shortened in the long axis, spoken of as being telescoped, and they may be comminuted. They always affect the contour by destroying the so called tuber-joint angle, as described by Boehler, and they may spread as the result of a split and give a broadened appearance to the heel.

The treatment of this type of fracture consists of restoring the tuber angle by traction. The results from such reductions are usually quite satisfactory. The lateral masses are replaced by lateral compression; the spring action of the foot is regained, and so the normal line of weight bearing is restored.

The greater problem is found in the type of fractures entering the subastragalar joint whether of the split or the crush variety; practically all are comminuted. These are difficult to diagnose and to reduce accurately, and have a high percentage of disability as well.

Most writers regard the fractures of the sustentaculum tali as being a distinct type, but when the anatomy is considered there is little basis for separating it in its classification from the other split fractures of the body of the os calcis. The anterior facet is largely, though perhaps not wholly, on the superior surface of the sustentaculum; and when this shelf is split off from the main body of the bone, the articular facet is

entered by the fracture line, and the relation between the anterior and posterior subastragalar joint facet is lost, which immediately makes for joint malalinement with all of the subsequent difficulties.

Since a large part of the body weight is carried on the sustentaculum, when it is loosened the foot is thrown into pronation, which also rotates the body of the os calcis into pronation. This results in bony impingement of the lateral side of the body against the lateral malleolus, and in addition, produces a rotation action at the anterior end of the os calcis at the calcaneocuboid joint with disruption of the function of the calcaneoscaphoid ligament.

The inferior calcaneoscaphoid ligament is always subject to injury in fractures involving the sustentaculum tali and is apt to be so in fractures of the neck or head of the os calcis in which it articulates with the cuboid. Fractures involving these structures must necessarily affect the complicated rotary and lateral movements of the forefoot. It was continued painful movement in these joints, associated with pain in the subastragalar joint, which prompted Conn to do his triple arthrodeses.

In doing a reduction by traction, such as Boehler recommends in this type of case, there is no way of knowing when an exact reposition of fragments has been accomplished; and if the compression clamp is applied to produce impaction, it is just a question of luck if perfect reposition and impaction occur.

Conn, who has reported his findings on opening these joints for subsequent arthrodeses, states, "An operative exposure has frequently disclosed serious articular disruption, when the roentgenograms were nearly or completely negative for joint involvement." And further, "We have come to consider any appreciable loss of lateral motion in the subastragalar joint, or the presence of thickening and untoward bone on the external surface of the tuberosity of the os calcis, as diagnostic of disruption of all of the reciprocal articulations of the calcaneum, irrespective of the roentgenographic findings." We have visible proof by this very conscientious observer of the effects of fractures entering these joints.

When there are several longitudinal splits, especially when the lateral cortex is separated, the problem of breadth and pressure beneath the malleolus becomes increased; and the disrupted peroneal tendons, which lie in a groove in this plate, split off from the lateral cortex.

In the care of this type of fracture then, it would seem that if these fragments could be perfectly replaced and pressed together to produce impaction so that they would hold their proper relation, a satisfactory repair would result.

Theoretically, this is correct but there are two stumbling blocks. First, it has been impossible to determine when this perfect reposition has taken place. So far, roentgenograms have not given this information satisfactorily. Second, an impaction of fragments inaccurately reduced is fatal to a painless result.

The other type of fracture entering the joint is even more severe and holds out little chance for a reduction, and a very poor prognosis should be admitted from the first. In this group undoubtedly the highest disability ratings occur. These are the comminuted crush fractures affecting especially the articulating surfaces of the subastragalar joints. If the fracture lines enter the joints or separate the facets, we know that the mechanism of that joint is interfered with, that is, that the different joint surfaces no longer act in unison; and should the fracture lines heal with this discrepancy, they can never work again with their former smoothness. In most instances these joint surfaces are pressed down into the underlying cancellous bone and become impacted there.

The disimpaction of these fragments becomes a real problem, since there is no way of holding or bringing force to bear on the individual fragments. Cotton attempted to disimpact them by the blows of a hammer on the side of the bone. Yoerg seems to have been successful with manual manipulation, but the problem still remains difficult in the hands of the average surgeon.

This difficulty has led to many attempts at open reduction to pry the impacted articulating facets up into their normal position, but these attempts have not received great popularity. Apparently, the success of any attempt at a perfect restoration of these badly comminuted fragments into the joints, which means ability to use the foot in a normal way with full function and without pain, is an improbability.

Accepting this as true, what then should be our goal as to a satisfactory result? We may say, an ability to walk with as little pain as possible. How can we find a yard stick with which to measure the disability? We should have some generally accepted standard. It may be that the State Industrial Accident Commissions will supply us with this standard. Then we could determine if what we are doing produces results which come up to the standard; and if not, we may investigate and find out where we have failed and develop methods of care which will improve our results. Since the great majority of such acci-

TABLE I.—ESSENTIAL FEATURES OF RECORD OF FRACTURE OF OS CALCIS

1. History and type of injury (fall or explosion). Age and weight.
2. Time elapsed between accident and time of reduction.
3. Types by x-ray finding: (a) intra-articular or extra-articular, (b) comminution, (c) tuber angle depressed, (d) foreshortening.
4. Exact type of treatment—specify clearly.
5. Time elapsed before weight bearing following reduction.
6. What type of apparatus, if any, used after weight bearing has been started.
7. Time elapsed between injury and return to duty.
8. Percentage of disability—as rated by Industrial Accident Commission.

dents occur in industry, we hope that the information which we seek will be forthcoming, not in only one state but in all states.

It is a generally accepted fact that of all injuries, the fracture of the os calcis is the most disabling one a man in industry can sustain. It might amuse you, as it did me when making inquiries through a state insurance company, to find that no separate records were made of this injury, and that there were no statistics of any kind available.

Much information unquestionably could be obtained which would be of inestimable value in solving our problems if we could induce all of our State Industrial Accident Commissions and the leading insurance companies handling compensation work to co-operate in gathering more accurate records, not only of the exact type of fracture sustained, but of what was done to overcome the malposition of the fragments, and how successfully this procedure of reposition had been accomplished. It could then be determined just how successful surgeons have been in the application of any given recommended type of treatment. I believe every case record should include the points shown in Table I.

The following is a quotation from Reich in regard to this: "In the discussion of the end-results very few of the writers have expressed an opinion as to what their criterion of good results actually is. Since the subastragalar joint has been the determining factor as to disability, the question has always arisen whether or not there is pain in the joint on weight-bearing, and as a corollary the patient has complained of less pain the greater the limitation of motion."

CONCLUSIONS

Traction has proved to be an excellent way of reducing fractures of the tuberosity where the comminution is not too great to allow a proper grasp of the fragments, so that the tuber-joint angle can be reduced and the spread of the bone can be compressed to normal.

Traction has been of great assistance in reducing fractures of the body of the os calcis entering the subastragalar joint. The amount of success obtained depends upon thoroughness of disimpaction, accuracy of replacement of the fragments before compression with the clamp, followed by sufficient fixation to allow firm bony union.

There is always bound to be some uncertainty as to the result from the closed method of reduction in all cases of fractures of the os calcis when the fracture lines enter the subastragalar or calcaneocuboid joints, or where the ligamentous support of the astragaloscaphoid joint has been disturbed, because of inability to obtain accurate roentgenograms by any means of roentgenography now at hand.

When the Boehler traction method of reduction has been strictly followed, the permanent disability rating has been greatly reduced especially in the less severe fractures of the tuberosity.

It must be understood that to accomplish a good result by the use of traction for reduction in fractures of the os calcis, one must have a thorough knowledge of the pathology and a keen appreciation of the use of the tools at hand. It is not a method to be attempted by the uninitiated and can serve no good purpose in his hands.

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CHEST INJURIES

FRANK B. BERRY, M.D., F.A.C.S., New York, New York

WITH the constantly increasing pace in civilization there is an accompanying rise in the incidence and importance of trauma in our lives and work. This stream of traumatic medicine and surgery flows to us from 2 sources: the ordinary accidents of civil life and occupational and compensable injuries. The first group arises out of a clear sky, as it were, with no background whatsoever; the second comes to us already surrounded by an aura of compensation and social security. The streams unite as the accident occurs and then diverge again, the first to healing, permanency of injury, or death, perhaps with future legal complications; the second terminates similarly, but in addition, slips back into the mists and uncertainties of insurance and compensation with the same possibility of late legalistic developments. The thorax, with its contents, is a region of the body frequently exposed to injury. The proper treatment of this trauma is at times of extreme urgency, and pre-existing conditions and slips in therapy may play an important part in the sequelæ. Although this presentation is concerned only with the immediate treatment of the more common types of thoracic trauma, still the previous history and psychology of the individual should be ascertained and considered.

All treatment of thoracic trauma is based on 2 principles: (1) treatment of surgical shock and hemorrhage if present, augmented by the free use of oxygen, oxygen and helium, or even the respirator, and the judicious employment of transfusions, which must be given carefully because of the upset cardiorespiratory balance; and (2) restoration of the thoracic viscera and of the intrathoracic physiology and dynamics to their normal status in shortest possible time with surgical interference only for definite indications, but then not delayed.

There are 2 conceptions of the anatomy and physiology of the chest and its viscera. There is the usual anatomical description of the pericardial and 2 pleural sacs with the enclosed heart and lungs, and the mediastinum with its important structures in direct communication with the neck above and with the retroperitoneal region below.

From the Division of Surgery, Columbia University, Bellevue Hospital.

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The protecting outer framework is the thoracic cage, partly rigid but with a good deal of mobility and elasticity and with many unprotected areas known as the intercostal spaces. The lower boundary is the diaphragm directly subject to injury, mobile, powerful, part of the time under tension. It can be injured also indirectly by pressure or strain and through its nerve supply. We must bear in mind, further, that under normal conditions the pressure in the pleural cavities varies from −9 centimeters of water in full inspiration to −3 or −4 centimeters in expiration. Due to the thinness of the pleura and the mobility of the mediastinal structures any alteration from the normal in one of the pleural cavities results in a similar change in the other 2 sacs. This effect upon the pericardium, however, is less marked because of its thickness and fixation to the diaphragm.

Since almost all injuries of the chest imply a potential pleural, lung, or heart involvement, a second conception of the respiratory mechanism may be helpful in considering the effect of trauma upon it. First, we have the spatial relationships and attributes of the lungs, namely, the thoracic cage with its normal mobility and the normal position of the organs within it, and the spatial factors of the lungs themselves, their structural features, vital capacity, tidal and reserve airs, and the part they play in pulmonary ventilation. It becomes apparent at once how injury may interfere with any of these functions by damage to the chest wall or lung or by the presence of fluid, blood, tension pneumothorax, or abdominal viscera within the pleural cavity. This problem becomes aggravated by deviation from the normal prior to the accident as from stiffening or marked deformity of the bony thorax, emphysema, fibrosis, or other disease of the lungs or pleura. Second, there is the purely intrapulmonary mechanism of gas exchange, the freedom of which may be impaired by trauma and shock, particularly if there is some pre-existing dysfunction already. Third, the cardiopulmonary balance is of great importance. If, therefore, we can successfully envisage this dual conception of the chest and the functions and relationship of its viscera, our treatment of thoracic trauma will be on a more intelligent and rational basis.

The great majority of injuries involve the chest wall, pleura, or lungs singly or in combination,

and may be either unilateral or bilateral. Following the immediate treatment for shock and hemorrhage and the necessary surgical dressing of wounds we must attempt as soon as feasible to restore the mechanics of the cardiorespiratory system to their normal state and then maintain an approximation to this as close as possible. This requires a frequent appraisal of the patient's condition by physical signs, roentgenograms, manometric readings of intrapleural pressures, and prompt aspiration or temporary closed drainage to correct any sudden pressure change, which might prove fatal if unrecognized or allowed to persist. Immediate major operative intervention should be reserved for wounds of the heart or esophagus, large wounds of the chest wall, hemorrhage from an internal mammary or intercostal vessel, and occasionally for injury of the lung itself in which a large vessel is torn and is not controlled by the ensuing pneumothorax. Immediate operative procedures may be rarely necessary for diaphragmatic rupture with acute ileus of the displaced intestines.

The usual types of chest trauma encountered are contusions and crushing injuries caused by blows, falls, and automobiles, and penetrating gunshot and stab wounds. These last are frequently made by ice-picks, which, together with bullet wounds, leave a chest wall almost intact; and unless a bit of clothing or other foreign matter is carried into these wounds they usually heal without infection.

MEDICAL, SPONTANEOUS, OR INTERNAL TRAUMA

A fairly large and interesting group of accidents occur quite spontaneously during fits of crying in infants, paroxysms of coughing or sneezing, sudden straining or wrenching movements with increased intrapulmonary pressure, or occasionally without apparent cause. The presence of disease —tuberculosis and bullous emphysema—greatly increases the possibility of such trauma. The injury may appear as fractures of one or more ribs due to coughing, as is not uncommonly seen in cases of pulmonary tuberculosis, the fracture usually occurring near the insertions of the serratus magnus muscle. The patient may feel a sharp pain and have local tenderness or he may not be aware that anything has happened except a sense of muscle discomfort or a little "pleurisy" and frequently neglects to mention it. Later the fracture will be seen in routine x-ray examination; there may be several fractures in the same patient, some healed and perhaps a more recent one.

Another accident of this sort is rupture of the lung, or spontaneous pneumothorax. Multiple episodes occur sometimes in patients with bullous emphysema due to the rupture of a bleb. Spontaneous pneumothorax appears also following the rupture of a tuberculous focus, the tearing of a small adhesion, or without any apparent cause. There may be very few symptoms, transitory pain, dyspnea, palpitation, or a flopping sensation in the chest; or on the other hand, they may be fulminating with the rapid development of tension pneumothorax or of empyema if infectious material has escaped. Such a course is usually caused by a valve-like tear in the lung so that air readily enters the pleural cavity through this rent but cannot escape; thus a tension pneumothorax soon develops with high intrapleural pressure, marked dyspnea, cyanosis, rapid pulse, mediastinal displacement to the opposite side, and high venous pressure. This must be relieved promptly and cautiously either by repeated aspirations or closed catheter drainage, otherwise the patient will die. If the tear is on the mediastinal surface of the lung, the adjacent, very thin pleura may also be torn permitting the escape of air into the mediastinum, thence into the neck along the vascular sheaths, and finally out through the cervical fascia into the subcutaneous tissues, from which point it may spread over the body and become so marked as to require relief by incision over the vascular sheath low in the neck. Fortunately, this is rarely necessary. It is the picture sometimes seen in infants after hard fits of crying and again in pulmonary tuberculosis with sudden rupture of the lung at its mediastinal attachment. Spontaneous pneumothorax may also be accompanied by an extensive hemothorax from the tearing of a vascular parietal adhesion. Unless the bleeding can be controlled by aspiration and artificial pneumothorax, the hemorrhage should be sought for and controlled in order to save the life of the patient. Finally, we have chemical trauma due to inhalation of smoke or gas with damage to the alveolar epithelium and the intrapulmonary mechanism of gas exchange. Although all of these except the last are usually handled by the internist and rarely encountered by the surgeon, nevertheless, they are forms of thoracic trauma just as much as are the commoner varieties about to be discussed.

CONTUSIONS AND ABRASIONS OF CHEST WALL EXCLUSIVE OF THE PRECORDIUM

Contusions and abrasions constitute the simplest form of external trauma and there may be nothing more than slight localized swelling or ecchymosis. On the other hand, depending upon the violence and extent of the blow or fall, the age

and condition of the individual, and the position of his body at the time of injury, most extensive skeletal and visceral damage may result with even occasional contrecoup manifestations. In the aged, for example, a relatively slight blow may cause extensive hemorrhage into the soft parts with its resultant dangers of imperfect absorption infection, and embolism. Sometimes a traumatic pleurisy may result, either dry, which clears in a few days, or with a clear or bloody effusion. There may be an associated, low-grade febrile reaction, which, if due to the traumatic pleurisy alone, should subside within a week or 10 days; otherwise lung involvement or the possibility of latent tuberculosis should be considered. In any event the patient should be kept in bed until the fluid has absorbed and the temperature has been normal for a week. If it appears that there are more than 200 cubic centimeters of fluid present, diagnostic puncture is always indicated. If a clear or slightly blood-tinged fluid is found, it is removed only to relieve pressure symptoms or perhaps to help hasten resorption when this is unduly slow. I do not favor replacing these simple effusions with air because it is not necessary. Furthermore, should tuberculous pleurisy occur, healing must take place by complete adherence of the pleural layers. This is aided by the natural absorption and organization of the fluid and hindered by the establishment and maintenance of a pneumothorax.

A hemothorax or pneumohemothorax, however, presents a different problem. The patient may or may not present evidence of hemorrhage. With only a small amount of blood present, nothing need be done. Otherwise the blood should be aspirated and replaced by two-thirds to three-quarters as much air. This maintains some tamponade at the bleeding point and facilitates healing of a torn lung; at the same time it permits re-expansion of the lung while keeping the pleural surfaces thin and free from the organizing blood clot. Unless the blood is removed a dense fibrothorax may result with extensive fibrosis of the pleura and atelectasis of the lung, possible permanent pockets of residual pneumothorax, and marked retraction of the ribs, mediastinum, and diaphragm. If the hemorrhage has been sufficient to cause symptoms, transfusion may be necessary. Failing a suitable donor, the blood from the pleural cavity may be removed into sodium citrate solution to 0.5 per cent dilution, filtered, and refused into the patient up to 12 hours following its appearance. If hemorrhage persists, it may be necessary to attack the bleeding point directly by open operation. Should this be the case, it is well to remember that a small, free, muscle graft is often helpful as a hemostatic. If held in place with moderate pressure for 5 minutes, any venous bleeding may be controlled, even bleeding from a moderate sized artery, particularly if the pressure is low, as in the pulmonary bed or after hemorrhage.

A hemothorax should be sought for not only in the injured but in the contralateral side as well—the contrecoup type. This may occur from a sudden wrench, strain, or convulsive effort which tears a vascular adhesion in the opposite pleural cavity.

It is generally recognized that contusions of the chest wall may cause a localized atelectasis of the underlying lung with subsequent bronchitis or pneumonia, or may activate a quiescent tuberculosis. The best prevention against atelectasis and pneumonia is a free and adequate oxygen supply, which is particularly true in the emphysematous or asthmatic individual; sufficient sedation should be employed to allay pain on respiration and thus prevent too much splinting of the injured chest, but yet not enough to depress respiration; a binder or strapping should be applied to effect the same purpose; a change of position with the patient semi-upright most of the time should be instituted; plenty of fluids are to be given to prevent viscosity of bronchial secretions; productive cough, if present, should be encouraged with the aid of benzoin inhalations and expectorants; and finally, direct bronchial aspiration should be performed if the patient is unable to rid himself of his secretions. Great care should be taken to ascertain what, if anything, the patient had in his mouth at the time of injury to guard against the possibility of an otherwise unsuspected foreign body lodging in the tracheobronchial tree. If there is any suspicion of this, repeated roentgenographic studies with the patient in different positions should be made and bronchoscopic examination demanded. A painstaking history with this in mind is of extreme importance.

PLEUROPULMONARY WOUNDS

Pleuropulmonary wounds are of 2 kinds: (1) those in which the chest wall is intact, and (2) those involving parietes, pleura, and lung. The common etiology for the first group, aside from the spontaneous injuries already mentioned, is from fractured ribs. Apart from the local tenderness and painful respiration, there may be hemoptysis, crepitus may be present, and there may be subcutaneous emphysema about the site of fracture along with the signs of pneumothorax. When this last happens, a pressure pneumothorax rarely

occurs as a decompression has already been made into the soft tissues, which are capable of absorbing very large amounts of air escaping from the lungs. The site of injury should be immobilized, sedatives given to allay pain, and the pneumothorax and hemothorax carefully watched and relieved if necessary. Pulmonary bleeding is generally controlled by the collapse of the lung.

Puncture wounds such as are made by bullets, ice-picks, and small knives are very similar. Unless clothing or some other foreign body has been carried into the pleura, infection is rather the exception than the rule. The treatment is the same as that already described, namely, aspiration of the blood and replacement with air after the patient has recovered from the initial shock. Hemorrhage with injuries of this type, however, is frequent, due to division of the internal mammary or intercostal vessels. This calls for prompt open operation with ligation of the bleeding point if the signs of hemorrhage are present; transfusion is also usually indicated. Mere bleeding from the wound does not demand operation unless it is evident that the source is still active. If, after injury, these patients are placed with the opening in the chest wall in a dependent position, it is astonishing how much of the blood from the hemothorax will trickle out through the wound. This has the added advantage of keeping the good lung uppermost, thereby preventing contralateral spill and likewise splinting the injured side. Here again, the opposite chest should be examined for possible contrecoup damage.

The most serious and distressing of the chest injuries are those with multiple rib fractures resulting from extensive trauma. In addition to the physical violence itself the patient has suffered a severe psychic shock with the immediate agony of impending death, followed by days of great suffering and sensation of suffocation. The patient is always in shock; there may be bilateral pneumothorax with extreme respiratory embarrassment; and there may be depression of the sternum with added venous obstruction. First, as with all thoracic trauma, the head of the bed is elevated. Second, the patient is placed in a very high oxygen or oxygen helium atmosphere, preferably by use of the B.L.B. apparatus[1], the use of an oxygen tent, or by nasal catheter; thus maximum ventilation and oxygenation with minimum effort is maintained and shock is combatted. Third, the pneumothorax and hemothorax must be relieved. Fourth, sedation or nerve block to relieve pain and restlessness, and support for the chest by sandbags or binder should be provided. Paravertebral nerve block is particularly valuable. When opium is used, frequent small doses are better than occasional large ones for there is less respiratory depression when the drug is so administered. Fifth, transfusion should be given and repeated if indicated. This should be done cautiously; the amount should depend upon the response of the patient. This and 100 per cent oxygen inhalation are the best methods we have to combat shock, and, by increasing the oxygen combining power of the blood, to overcome also the acapnia that may be present due to rapid shallow respirations with resultant washing out of the carbon dioxide. Sixth, cardiac or pericardial injury should always be suspected in this type of injury. Seventh, elevation of a depressed manubrium or sternum may be required. At best the mortality is high, the incidence of pneumonia considerable, and the later reconstruction of the survivors is often difficult and discouraging.

[1]An apparatus designed by Boothby, Lovelace, and Bulbulian for the administration of oxygen or oxygen and helium.

OPEN WOUNDS OF THE CHEST WALL AND PLEURA

If there is a large gaping wound in the chest wall and pleura, the opening should be covered or packed immediately with anything at hand. As soon as possible it should be carefully débrided, the wound in the lung, if present, sutured, the lung re-expanded, the pleura and soft parts closed tightly, and closed drainage or suction provided up to 10 centimeters of water at the dependent part of the pleural cavity. If there is no evidence of suppuration, this may be discontinued in 3 or 4 days. If the wound is not large and sucking, simple cleansing and suture are required with further operation only to control bleeding. Following this the patient is placed with the wound down for the reasons already mentioned, and 24 to 48 hours later the pleura is aspirated.

RECAPITULATION

1. I cannot emphasize too strongly the necessity of aspirating a hemothorax of over 200 or 300 cubic centimeters. The continued presence and organization of blood in the pleural cavity causes a marked degree of fibrothorax, the late appearance of empyema in the residual thick-walled pleural space, and atelectasis and bronchiectasis in the underlying compressed lung.

2. Except for aspiration and air replacement in hemothorax, the treatment for wounds of the chest wall, pleura, and lungs is non-operative. Operation should be undertaken only to close large wounds and to control bleeding from the intercostal and internal mammary vessels and

only rarely from the lung itself when this cannot be controlled by pneumothorax. With this method of treatment Elkin has reported a mortality of only 6 per cent in a series of 553 cases, including 11 penetrating wounds of the heart.

WOUNDS OF THE PERICARDIUM AND HEART

These are of 2 kinds, the penetrating and the blunt injuries. The former are often quickly fatal from hemorrhage especially when the auricles are penetrated. A certain number, however, particularly wounds of the ventricles, are amenable to treatment and prompt action may mean the difference between life and death. When the patient is seen, there is usually a small wound to the left of the sternum between the third and sixth spaces, or along its right border. The wound may be bleeding freely or there may be merely a persistent trickle, and there is often a history of injury followed by a period of activity and then sudden syncope. There is a gray cyanosis, distended veins of the neck, increased venous pressure, small or absent pulse, dyspnea, increased cardiac dullness, absence of heart sounds, and low or absent blood pressure because of an acute compression of the heart. Diagnosis is made positive by fluoroscope which reveals an absence of cardiac pulsation. In doubtful cases and even in the presence of apparent death up to 15 or 20 minutes immediate operation is indicated. This acute compression is caused by bleeding from the heart into the pericardium with resulting compression or tamponade. Two costal cartilages, the third and fourth, or fourth and fifth, are resected, the ribs spread gently, and the pericardium opened. The blood is evacuated and the wound in the heart sought for and repaired. A transfusion or refusion, or if these are not possible, an infusion, is started and the heart is massaged gently and rhythmically. Even though no movement is at first visible, contractions may begin again if this procedure is continued for some minutes; adrenalin may be injected into the ventricles if contractions do not commence or if their response is weak. Meticulous asepsis, hemostasis, and gentle handling of tissues are essential. The pericardium is closed without drainage or left open into the pleura, and the pleura, if opened, is aspirated and the lung reexpanded. The patient is placed in an oxygen tent, or a B.L.B. apparatus is employed. If these are not available, intranasal oxygen can be administered following operation. A recurring accumulation of fluid in the pericardium or pleural cavity during convalescence must be watched and aspirated as indicated. These injuries are not as fatal as was formerly supposed. Bigger, in a collected series of 141 cases, including 11 of his own, gives a mortality of 50 per cent. Success lies in early diagnosis and prompt operation; when any doubt exists, operation is usually the more conservative course.

There is a small group of cases, however, described by Bigger and mentioned by Elkin, in which the diagnosis is doubtful and in which conservative therapy should be followed. The author has had 1 such case. The wound is in the precordial area but the patient has recovered from his shock; the heart sounds are audible and may have a tinkling or splashing quality; the venous pressure is low and there are signs of blood in the pleura. This patient probably has a superficial or small penetrating wound of the heart with a wound of the pericardium into the pleura allowing prompt decompression. The small opening in the heart wall becomes plugged with clot and healing will take place. Waiting with careful observation is justified in this group, although one should be ready with prompt surgical interference should bleeding recur or tamponade develop.

Little attention has been given to the blunt or non-penetrating injuries of the heart and yet it is becoming increasingly apparent that these comprise an important group. During the past 10 years Bright and Beck in this country and several foreign workers have studied this type of trauma both experimentally and clinically. Very recently White and Glenby have written comprehensively and conservatively on the same subject reviewing the experimental work to date and citing numerous case reports. Hallermann states that from January 1, 1931 to August 1, 1934, 3,751 autopsies were performed at the Berlin Medicolegal Institute, of which 124, or 3.2 per cent, presented cardiac injuries due to blunt trauma. It is strange that so little attention has been given this subject in this country. Furthermore, much information can be obtained experimentally by studying injury and repair in healthy and artificially damaged hearts. Great credit is due to Beck and his co-workers and to Schlomka and Kuelbs for the important work they have already done along these lines. There is still much more to be accomplished, however, before a final appraisal of these injuries and their sequellæ can be made.

Brahdy and Kahn state this admirably: "After the condition of the patient prior to the accident has been estimated, the nature of the injury itself must be considered. A detailed knowledge of the type of injury is extremely important and usually can be obtained from a detailed description of the accident. Was it a direct trauma (a blow or fall), an indirect trauma (a lift or a twist), or a psycho-

emotional injury"? Inasmuch as we are discussing only organic injury of the heart resulting from blunt trauma, crushing injuries, and sudden strain, the psycho-emotional injury will not be considered, although of itself it may be productive of alterations in rhythm and a cardiac psychoneurosis almost identical with some of the organic diseases.

Cardiac injury should be suspected following any blow over the left chest, the impact of the steering wheel in automobile accidents, or crushing of the chest. It should be thought of also in cases of falls from any appreciable height and considered as a possibility following violent and sudden strain or sudden severe pressure on the abdomen. White and Glenby give 5 simple and almost self-evident rules, which are, nevertheless, often overlooked: First, the more severe the injury to the thorax, the greater likelihood of cardiac damage. Second, "the more diseased the heart is, the more easily it is injured by trauma." Third, the more nervous and sensitive the subject, the more numerous will be the symptoms following trauma. Fourth, the signs of cardiac injury may or may not be evident on superficial examination. Fifth, prognosis depends not only on the damage to the heart itself, but likewise on the associated lesions and efficacy of treatment.

Proper examination consists of careful inspection, palpation, percussion, auscultation, electrocardiogram, roentgenogram, and blood pressure determination. The results of such examinations should be recorded carefully and compared with repeated similar re-examinations during convalescence. Changes in the size of the heart and its sounds, the development of murmurs, alterations in rhythm, divergence from normal in the electrocardiogram, syncope, precordial pain, and attacks of angina pectoris should be noted especially.

Myocardial damage resulting from blunt trauma may vary from a small area of edema with a few pericardial or subendocardial hemorrhages to complete rupture. The extent depends on the violence of the injury and the pre-existing condition of the heart. A diseased heart is much more liable to injury than a normal one. Kuelbs and Strauss have verified this experimentally using cats, dogs, and rabbits, and conclude that normal animals withstand even recurrent trauma without permanent injury. Experimentally produced cardiac defects, however, increase the sensitivity of the cardiac muscle so that even slight trauma may cause marked hemorrhage or acute cardiac death.

Under certain conditions, perhaps when the intraventricular pressure is high as in late diastole, even a normal heart may be affected seriously by relatively mild trauma. Deutsch reports the case of a professional boxer 26 years of age in excellent physical condition and with normal heart and vascular system. In the third round of his last match he received a blow over the apex of the heart and died immediately. At autopsy, dark red, delicate hemorrhages were found in the anterior mediastinum. The heart was rigid and contained only fluid blood; the wall of the left ventricle was 16 to 17 millimeters thick and the valves and coronary arteries were very delicate. The aorta was small and normal. The condition was described as cardiac enlargement without marked dilatation and blood stasis in the other viscera. Deutsch's explanation is that because of severe and acute physical strain and accelerated breathing the thick and rigid heart muscle showed a particularly increased tonus at the moment of death. This description agrees with the prolonged "perisystole" mentioned by Schlomka.

The findings and opinion of Schlomka merit recording in detail. Cats and rabbits were used. (1) Simultaneously with the trauma the electrocardiogram shows disturbance of cardiac function; (2) coincident with the trauma the blood pressure usually shows a considerable decrease in proportion to the severity of the chest trauma; (3) this drop in blood pressure is accompanied by a temporary and often marked rise in venous pressure; (4) commotio cordis is typically associated with a frequently pronounced acute traumatic dilatation of the heart, preferably the right heart. In some cases there occurs a later secondary dilatation with recurring drop in blood pressure and rise in venous pressure and death. (5) Blunt trauma causes instantaneous death usually from fibrillation, from a fatal Stokes-Adams syndrome, or rarely from sudden prolonged perisystole; (6) surviving test animals frequently develop chronic heart lesions, generally myocardial, with resulting chronic dilatation.

Schlomka states that these experimental findings are verified clinicopathologically in (1) pulse irregularity as an acute symptom from extrasystoles, auricular fibrillation, disturbed conductivity with blocking, or thready pulse due to pronounced and prolonged drop in blood pressure; (2) acute traumatic dilatation may be present; (3) instantaneous death may occur from ventricular fibrillation or as an apoplectiform manifestation of Stokes-Adams syndrome.

The entire complex of acute cardiovascular and cerebral symptoms following blunt trauma of the chest wall must be interpreted as commotio cordis with subsequent acute and more or less lasting cardiac insufficiency. The electrocardiogram ex-

hibits coronary spasm indicating likewise a functional derangement in blood supply. When this condition is present, absolute bed rest and strict diet should be ordered; any surgery should be delayed if possible; venesection is indicated to relieve cardiac dilatation; vasodilators should be prescribed; warmth rather than an icebag should be used to relieve cardiac pain; intracardiac adrenalin is indicated if the pulse is impalpable and heart sounds cannot be heard; and artificial respiration may be necessary.

Quite apart from myocardial injury with the possible ensuing signs of dilatation and acute cardiac failure of greater or less degree, effects on the heart of non-penetrating trauma may manifest themselves as changes in rhythm such as extrasystoles, tachycardia, or auricular fibrillation, disturbance of the conduction system, and angina attacks. In 1924, the author assisted Dr. S. W. and Dr. A. V. S. Lambert in the care of a patient of 57 who had received a violent blow over the precordium. There was syncope of very short duration following which he complained of severe paroxysmal precordial pain. Physical examination of the heart was persistently negative except for extrasystoles. The symptoms were paroxysmal pain, anxiety, slight dyspnea, and upper abdominal distention. Unfortunately, no electrocardiogram could be obtained because of the fact that he was at home and a portable electrocardiograph was not available. Absolute rest, daily colon irrigations, and morphine were prescribed, and later 0.1 gram of digitalis was given intravenously each day. The acute symptoms persisted for about 10 days, following which he made an uneventful convalescence over a period of 4 weeks and has remained well since. Here was a case of cardiac trauma from contusion manifesting itself by short syncope, extrasystoles, paroxysmal cardiac pain, and upper abdominal distention.

Rarely also the heart itself or one of its valves, may be ruptured subsequent to blunt trauma of the thorax, crushing, great strain, or sudden compression. Bright and Beck have analyzed the reported cases of cardiac rupture, and Antonini has discussed rupture of the valves. He points out that the immediate symptoms may consist of cough and hemoptysis or there may be none at all, and a murmur appearing at a variable time after the accident may be the only sign of rupture.

TREATMENT

In treating these various types of cardiac injury repeated and careful examinations, with electrocardiographic aid, should be made as already mentioned. Absolute bed rest and light diet are essential. A Gatch bed is distinctly preferable. Every motion should be spared the patient, and sufficient sedation to control restlessness administered. All but the most urgent surgery or manipulations elsewhere on the body should be avoided. Signs of even slight cardiac failure should be carefully sought for and digitalis prescribed as indicated. Oxygen therapy is employed for dyspnea, cyanosis, and signs of cardiac failure. To reduce irritability and disturbances in the conduction system quinidine, or, for auricular fibrillation, digitalis may be indicated. An icebag may be helpful in the rapid arrhythmias. When the disturbance manifests itself by attacks of angina indicative of possible coronary spasm, vasodilators and oxygen are indicated and heat rather than cold should be used over the precordium; this is also true if acute dilatation or other signs of myocardial damage are present. Venesection is indicated in acute traumatic dilatation. Abdominal distention must be controlled by the judicious employment of cathartics, poultices or stupes, irrigations, and pituitrin, pitressin, or prostigmin as needed. Bed rest should be continued for from 5 to 8 weeks and a slow resumption of activity insisted upon. As soon as a diagnosis of an injury of this kind is suspected, the assistance and advice of a competent internist should be sought and therapy planned with him.

THE ESOPHAGUS

Although it may not be generally recognized, injuries of the esophagus are not infrequent. Needless to say they are extremely serious because of the thinness of its wall, its relatively scant blood supply, the poor resistance and localizing ability of the loose areolar tissue of the mediastinum to infection, and the type and virulence of the infection itself, which is always a mixture of aerobic and anaerobic organisms. Trauma is of 4 varieties: (1) chemical, (2) external, (3) internal from foreign bodies such as bones, and (4) instrumentation. The treatment for the first group is largely expectant with sedation and neutralizing and bland washes in the early stages and later dilatation as necessary. Wounds of the esophagus should be thoroughly débrided, carefully repaired, and the wound packed with active medicinal zinc peroxide. Internal trauma caused by foreign bodies or instrumentation is of frequent occurrence and is all too often followed by a diffuse mediastinitis or localizing abscess. If a person injures the esophagus by swallowing a bone or some other sharp foreign body, he should be esophagoscoped immediately, if possible, to

make sure that it is no longer present, and, if present, it should be removed. If, following trauma by such foreign body or from instrumentation the signs of perforation and spreading infection appear, prompt operation is not only indicated but is imperative. Such signs are chill, temperature, painful deglutition, and soreness in the neck or mediastinum. Physical examination may show tenderness or swelling, occasionally beginning subcutaneous crepitation, or nothing. Roentgenograms may show beginning abscess formation or the appearance of edema and gas bubbles. Esophagoscopy will demonstrate the site of the perforation. Drainage should be established by the shortest possible approach as determined from the information at hand. This may be directly into the mediastinum or at base of neck anterior to the sternomastoid muscle or by a collar incision. A tube should be inserted and the wound left wide open and packed with active zinc peroxide if available, if not, hydrogen peroxide or Dakin's solution, and the foot of the bed should be elevated.

It is difficult to understand the hesitancy with which many surgeons approach these esophageal lesions and their associated infections. Because of the very nature of the infection, its location, and the recognized poor reaction of the tissues toward localization, there must be no compromise or delay in establishing surgical drainage once the diagnosis is established and the approximate site determined. The lower pharynx, upper esophagus, and upper mediastinum may be readily reached by an incision low in the neck along the posterior or anterior border of the sternomastoid muscle. As the muscle and vessels are retracted the esophagus is approached. If infection is present there will be edema, bubbles of foul-smelling gas, or even a poorly walled-off abscess cavity. If the infection is limited and high in the neck, incision posterior to the sternomastoid muscle permits drainage by merely displacing the vascular sheath forward. Lower in the neck and in the upper mediastinum the incision is made along the anterior border of the muscle and this and the vascular sheath retracted laterally. This is not always possible, however, for where there is widespread infection without any evidence of localization the best approach is by a generous low collar incision, thus providing the freest drainage possible to both sides simultaneously. Counter incisions may be made as indicated at a later date. If the infection is further down but still above the level of the third rib, it may be drained by resecting the second costal cartilage on the right, displacing the pleura, and entering the upper mediastinum directly. The lower esophagus may be approached from either side by removing a portion of one or more ribs from their angles backward including their articulating transverse processes of the vertebræ. As the pleura is displaced forward, the mediastinum is entered and readily explored. With the mediastinum thus accessible throughout its entire extent delay in operation is indefensible. The mortality, high at best following this type of injury, increases, however, as surgical drainage is delayed.

SUMMARY AND CONCLUSIONS

1. Except for large and dirty wounds, bleeding from internal mammary and intercostal vessels, and persistent pulmonary hemorrhage, the treatment of injuries of the chest wall, pleura, and lungs is conservative. All therapy is directed toward restoring the normal anatomy, physiology, and dynamics within the chest as soon as possible. Aspiration of hemothorax and partial replacement with air is recommended. Immediate surgery is advised only for large or dirty wounds, and for active bleeding, usually from an intercostal or internal mammary vessel.

2. Immediate surgical repair is urgent for penetrating wounds of the heart. Blunt and nonpenetrating cardiac trauma may result in organic —either myocardial or valvular—functional, or psycho-emotional disturbances. Diagnosis and treatment are outlined.

3. The treatment of esophageal perforation or injury is surgical and the use of zinc peroxide is recommended.

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TREATMENT OF FRACTURES OF THE SHAFT OF THE HUMERUS BY HANGING CAST

JOHN A. CALDWELL, M.D., F.A.C.S., Cincinnati, Ohio

SEVERAL features about the humerus cause fractures of that bone to present special problems in treatment. (1) It is the most freely movable long bone. Articulated above with the scapula by a ball and socket joint, the humerus has movement in all directions, and its movement can be amplified by movement of the scapula. (2) Its entire function is that of a lever, so that nearly all stress is in tension or at an angle to its long axis. The bone has to stand comparatively little stress in compression. (3) When at rest while the person is standing, the axis of the bone hangs vertically and is influenced by gravity alone. These individual features of the humerus make it necessary to depart from common lines of treatment of fractures of long bones, and have caused those who give special attention to management of fractures to be grouped into 2 general classes:

The first of these might be designated properly as the rigid immobilizationists. Those who subscribe to the requirements of this method insist upon accurate reduction and then fixation in a neutral position for as long as is necessary to secure enough union so that displacement will not occur with slight motion.

There are many practical difficulties to the use of absolute fixation of the humerus. It is easy to reduce a transverse fracture, but apposition of fragments is difficult to maintain; and when the break is very oblique or spiral, apposition is impossible. In these cases alinement must be maintained by continuous traction, and on a humerus this traction must be exerted with considerable caution lest distraction of fragments follow and cause delay or even failure of union. We have found that when continuous traction on the humerus is necessary an excess of 6 pounds, with the elbow flexed, must be employed with great caution and should be checked frequently by fluoroscopic observation or films.

After reduction or alinement has been attained, the apparatus to maintain position must immobilize the shoulder and elbow; consequently, the body must be included in the dressing. Since rigid immobilization is followed by rapid wasting of the muscles about the shoulder girdle, particularly the deltoid, the arm should be fixed in as much abduction as possible, so that when dressings are removed, gravity will cause the arm to fall to the side and the deltoid muscle will not have been stretched. The common dressings in use are some form of aeroplane splint or a shoulder spica case, and the usual position is the humerus abducted 60 to 90 degrees and the elbow flexed; occasionally, the humerus is rotated externally.

Such a dressing is cumbersome and uncomfortable; it interferes with bathing, and since street clothing cannot be worn over this dressing, confinement to the house is enforced. Such a dressing

From the Fracture Service, Department of Surgery, Cincinnati General Hospital.

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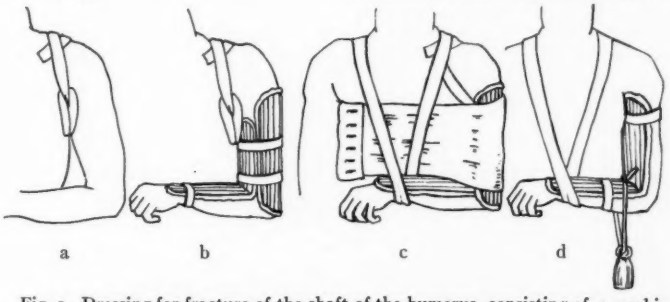

Fig. 1. Dressing for fracture of the shaft of the humerus, consisting of, a, pad in axilla held by a strap over shoulder; b, molded padded plaster-of-Paris, metal, felt, or wood splints applied with forearm pronated; c, body swathe (muslin or gauze) and sling; d, weight attachment to be used if traction is needed.

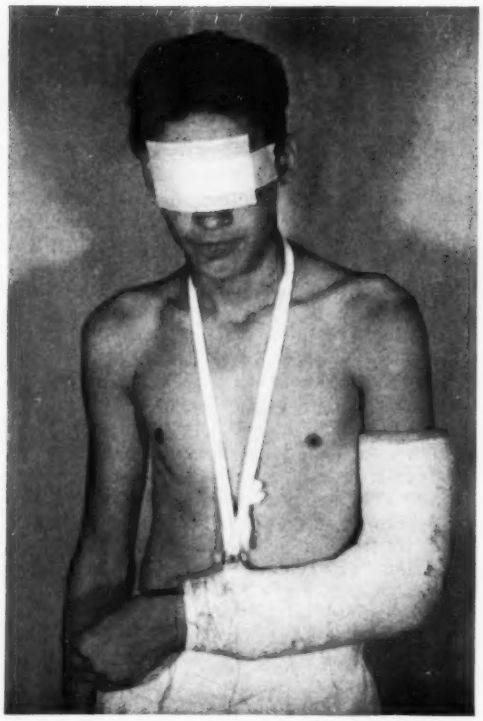

Fig. 2. Hanging cast which accomplishes the same result as the methods illustrated in Figure 1.

Fig. 3. Showing the possibility of passive rotation with the arm in a hanging cast.

is well nigh impossible in the obese and others whose strength and endurance are reduced.

Those who in the management of fractures do not accept the necessity for absolute immobilization depend upon some form of traction in the long axis of the bone. This has long been a method of treatment in fractures of the femur as well as the humerus and, while accurate apposition of the fragments may not be accomplished, good functional result without deformity is usually secured. In the humerus, traction is accomplished by gravity; the weight is supplied by that portion of the arm below the fracture, and when necessary this weight may be augmented by additional weight about the elbow. An old method was to apply coaptation splints to the surface of the humerus from shoulder to elbow, flex the elbow joint to 90 degrees, and hang the forearm by a narrow sling about the wrist. In this position the humerus was vertical when the patient was standing; and if additional weight was required, a tobacco bag containing a variable quantity of shot was hung as far up on the forearm as possible. The most objectionable feature of this dressing was the swaying, dangling weight which was difficult to keep in position and constantly caught and struck on objects which the patient passed.

For some years we have employed a modification of this dressing which does not alter the principles employed, is free from the objections mentioned, and when once applied does not need further attention. It has come to be known as the hanging cast or traction cast and in our hands as well as some others has given a high proportion of good results with least annoyance and discomfort to the patient. A plaster cast is applied from the axilla to the hand over stockinette only. The elbow is flexed to 90 degrees; the forearm is in mid-pronation. A wire loop is incorporated in the case just above the base of the thumb and through this a piece of bandage is threaded which passes about the patient's neck. We instituted the use of this loop when we found that patients would move the sling up the forearm toward the elbow

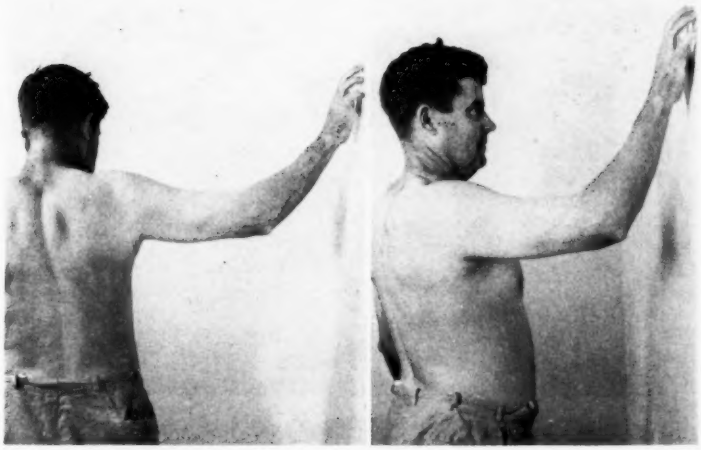

Fig. 4. Early active movements to restore flexion and extension of the shoulder joint after cast is removed.

in order to relieve the pull on the shoulder. When the fracture is high, near the insertion of the deltoid, the upper fragment is often abducted and causes angulation at the break. In such cases we place a wad of sheet cotton over the inner aspect of the elbow and cover this with plaster. This acts as does a Mitteldorph triangle, abducts the lower fragment, and alines it with the upper fragment.

When the fracture is very oblique, spiral, or comminuted so that reduction can not be accomplished, or when the fracture is compound, or the patient badly shocked, our common practice is to put the patient to bed and apply balanced traction with the arm abducted 45 degrees and the forearm flexed to 90 degrees. When reaction has subsided and the patient's vigor has returned, the hanging cast is applied.

Patients are cautioned not to rest their elbows on chair arms or other objects and to sleep with their shoulders well elevated. After 7 to 10 days the patient is instructed to rotate the humerus within limits of comfort, and in 2 weeks he is

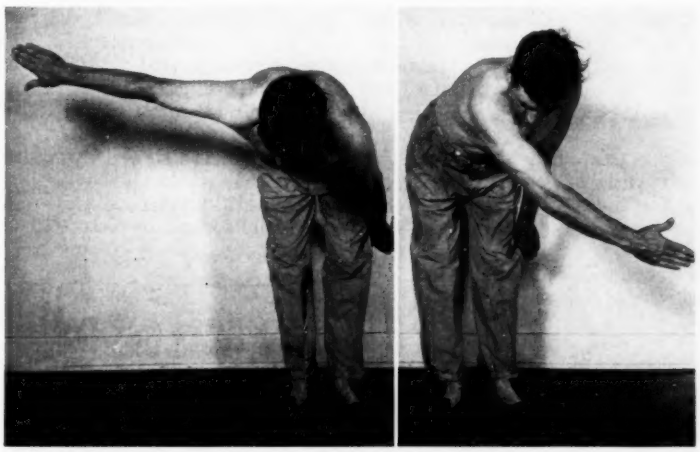

Fig 5. Active movements to restore abduction and adduction after cast is removed.

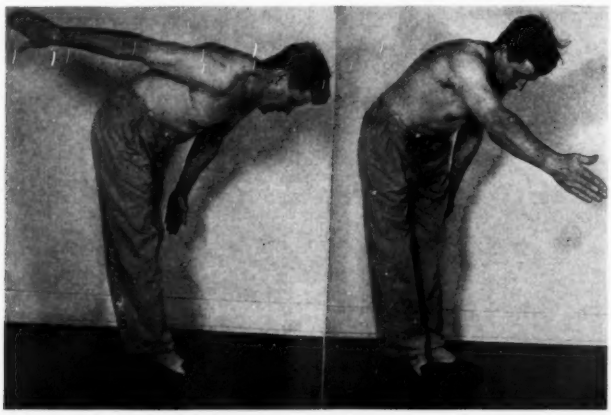

Fig. 6. Crawling exercise to improve restoration of deltoid action.

directed to abduct his arm as far as he can comfortably. Usually in 4 weeks the cast can be removed and a sling substituted, and movements of rotation, swinging, and abduction can be amplified.

With this treatment and regimen we have found that restoration of abductor function is delayed no more than when an aeroplane type of dressing is applied. Our reductions, while rarely showing 100 per cent apposition, do not often fall below 50 per cent. Union is usually complete in 8 weeks. It may be several months before the patient can raise his arm to the vertical position but we have rarely failed to have this function return eventually.

The series of cases analyzed consisted of 108 fractures of the shaft of the humerus. Fractures of the surgical neck and supracondylar fractures were not included. The 108 cases were located as follows: upper third, 25; middle third, 62; and lower third, 21.

Of the 59 patients treated by hanging cast, 22 had treatment for variable periods by balanced traction in bed. The shortest period of this treatment was 3 days, the longest 95 days; the latter was necessary because of extensive comminution from a gunshot wound followed by infection. The results obtained were as follows: Good union and function, 85; poor position, good function, 6; poor function, 3; non-union, 1; delayed union, 4; result not ascertainable, 9.

The 3 patients whose results were classified as poor had impaired abduction of the humerus. These were patients who were inactive by reason of age or other disability and consequently unable to co-operate.

While the hanging cast method was used more than all other methods combined, the others used were similar in principle, except that used in the 3 cases in which an aeroplane splint was used. That is to say that in all but the 3 patients in whom abduction was used, the arm was permitted to hang vertically so that gravity was exerted in the long axis of the humerus.

The principal argument in favor of an abduction method is that during convalescence it reduces the disability occasioned by the stretching of the deltoid muscle and by the delay of restoration of abduction which result. If a vertical hanging method is followed by results equal in this respect, this method is superior in every other way because of its greater simplicity and lighter weight.

A fair, composite picture of the course in a moderately vigorous, co-operative adult would be

TABLE I.—TYPES OF FRACTURE

	No.
Gunshot wound	9
Compound	1
Oblique	30
Comminuted	18
Transverse	33
Spiral	17

TABLE II.—TYPE OF TREATMENT

	No.
Swathe binding arm to side of chest	28
Mitteldorph triangle and swathe	7
Aeroplane splint	3
Pin traction followed by sling	6
Open fixation Parham Martin band	2
Open fixation plate	1
Open fixation wire	1
Hanging cast	59
No treatment	1

as follows: The application of a hanging cast for 6 weeks, with gradually increasing motion as discomfort diminished. This would be followed by a sling at 90 degrees with light use of the arm and several swinging exercises during the day. When all dressings are removed in 8 weeks, we would expect the patient to flex the elbow to 40 degrees, extend it to 135 degrees, abduct the humerus to 60 degrees, and have full rotation. In 3 months he should have full restoration of function.

In 19 cases, all adults, complete restoration had taken place after 3 months had elapsed and in some of these the period was less. One of these patients was 73 years old. Four had some impairment after 1 year, but in each case there was some good reason present for the delay.

One patient had an osteomyelitis following open operation. Four patients had radial nerve injuries, 3 of which were explored. Full radial nerve conduction was restored in all. In 1 patient there followed an acute painful osteoporosis.

CONCLUSIONS

1. Since the humerus when unsupported hangs vertically when the patient is erect, this position will in most instances be followed by alinement of the fragments when the fracture is situated in the shaft.

2. The hanging cast reduces lateral motion, and when some lateral motion does take place it is assured that both fragments move through the same arc; and it is a convenient and comfortable way of applying traction by increasing the weight of the arm.

Abduction methods on an ambulatory patient are cumbersome, uncomfortable, and fatiguing and can not be used for all patients. These methods also prevent active movement which is the most effective method of restoring function.

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SYMPOSIUM: OPHTHALMOLOGY

PARALYSIS OF THE LOWER LID AND SCLERAL SCARS AND GRAFTS

VILRAY P. BLAIR, M.D., F.A.C.S., and LOUIS T. BYARS, M.D.,
St. Louis, Missouri

PARALYSIS OF THE LOWER LID

PARALYSIS or destruction of the orbicular muscle fibers of the lower eyelid can cause quite different and more severe symptoms than a similar catastrophy in the upper lid. Constant elevation of the latter can be caused by overactivity of the levator palpebræ muscle, and this is always in evidence; but as long as the tone of the lower lid is present, lack of normal activity is rather unnoticeable, especially if there is any persistence of those involuntary lid movements that normally cause the open fissure to frame the iris somewhat accurately during its ordinary up and down excursions. It is when the tone is lost that the paralyzed lower lid begins to attract attention subjectively and objectively (Figs. 5 and 6). Contact of the lid with the globe is the normal condition, and when this ceases there is a distinct sense of discomfort. The overacting levator muscle has no tendency to pull the upper tarsus away from the globe even when the latter is flaccid, as both gravity and a potential vacuum act to maintain this contact. On the other hand, gravity, which helps to maintain the contact of the upper lid, here has the reverse influence, and atmospheric pressure lends no helping hand. The immediate reaction to even a slight separation of the tarsus is a sense of discomfort, which may develop into a distinct irritation or inflammation when particles of dirt or grit accumulate in the space formed between the globe and the lid. Excessive tearing may also result.

The most common cause of lid paralysis is total or partial loss in continuity of the seventh nerve (Fig. 8), while in some cases it is due to a local destruction of the muscle (Fig. 1). A binding scar or a depressed lower orbital border can prevent the lower lid from rising to its natural level or may even be the cause of an ectropion (Fig. 2).

Presented in the Symposium on Ophthalmology before the Clinical Congress of the American College of Surgeons, Philadelphia, October 16–20, 1939.

In some cases an external canthoplasty will be sufficient for the correction of these conditions; in others more intricate measures must be adopted, the object of all of which is to hold the lid border at the level most common to its fellow and in good contact with the globe. With such a correction a static lower lid can be quite serviceable. In cases in which it is appropriate, the restoration of motor innervation is the ideal plan (Fig. 8). In the following reports, different plans to which we have resorted are illustrated:

CASE 1. This was a case of distortion and a purely local paralysis of the lower lid due to excision of a paraffinoma which involved the whole lower lid and which resulted from the injection of an oil into the lacrimal sac in an attempt to force an opening through a blocked nasal duct. The inner two-thirds of the lid sagged away from the globe, but in the outer third the border was inverted by scar and the lashes swept the sclera. We first attempted to raise the lid by chiseling off 3 millimeters of the lower bony border; the latter was raised by inserting an ivory wedge. This plan has worked nicely where a lid has been pulled down by a depressed fracture of the border, but it did no good in this case. The correction was accomplished by the use of a flap taken from the upper end of the forehead—base in front of the ear—and switched into a transverse opening in the lid just below the tarsus. If the cheek tissues on which the lower border rests will give normal support, this rather stiff flap should in turn hold the tarsal border in place. At the same operation an arrowhead incision was made just internal to the inner canthus, and the point of the latter was drawn into the apex of this defect; this was done both to narrow the canthus and move it inward. Figure 1a shows the condition at first examination. Figure 1b shows the final result, which was quite satisfactory in every way. The grafted forehead defect is entirely hidden by a slight draping down of patient's hair. The excess tearing was relieved and the patient was satisfied with the appearance. This result forestalled a damage suit.

CASE 2. This patient had total paralysis of lower lid due to trauma and scar. Patient was in an automobile accident; the tissues of the cheek were torn outward as a flap, the skin tear running downward from near the inner brow past the corner of the mouth, on down to the lower border of the mandible, and from thence back to the angle of the jaw. Above, a tear ran backward across the middle part of the lower lid. There was a parotid fistula, loss of

Fig. 1. Case 1. a, left, Distortion and local paralysis of lower lid at first examination; b, result after operation.

a b c

Fig. 2. Case 2. Patient with total paralysis of lower lid. a, Condition at first examination; b, flap in place with pedicle still uncut; c, after cutting the pedicle, outer end of transplant fixed well above level of outer canthus.

function of the temporofacial branches of the seventh nerve with inability to close the eye, and eversion and sagging of the lower lid on the left side. An attempt was made to correct the droop and ectropion by somewhat the same plan as was used in Case 1, but to give a positive upward pull. The insert was cut crescent shape and the points anchored above the level of the fissure; but in spite of several adjustments, this was never quite as satisfactory because the paralyzed cheek failed to give support to the transplanted flap and the patient's physical condition did not warrant the use of fascia loops into the cheek. Figure 2a shows the condition at time of first examination. Figure 2b

Fig. 3. Case 3. Paralysis of lower lid incidental to investigation of an orbital antral tumor. a, above, Condition before implantation of cartilage; b, result after operation.

Fig. 4. Case 4. Traumatic paralysis: ectropion at inner canthus. a, above, Illustrates sagging of lid away from the globe especially on its inner half; b, result after operation.

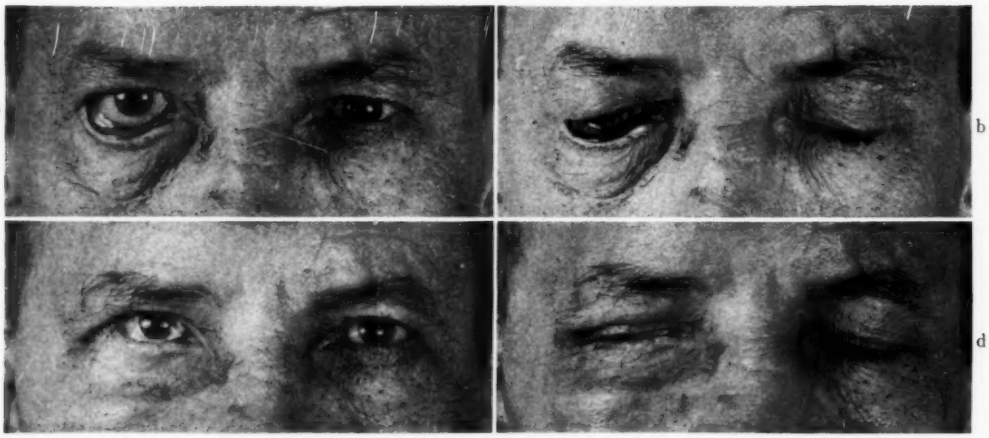


Fig. 5. Case 5. Total paralysis of right side of face from peripheral nerve destruction. a and b, Illustrate ectropion of lower lid with overactivity of the levator palpebræ muscle; c and d, result after operation.

shows the flap in place, pedicle still uncut, and illustrates how the point of this flap was put internal and above the level of the internal canthus. Figure 2c shows the last photograph taken just after cutting the pedicle, and also shows that the outer end of the transplant is fixed well above the level of the outer canthus to make a hammock-like support for the tarsus. An external canthoplasty here might have been helpful.

Case 3. Paralysis of the lower lid incidental to investigation of an orbital antral tumor. In this instance, the lower lid was drawn downward by scar and was quite flabby, and a lift with either autofascia or forehead flap would not have been suitable. Through an incision made at the lower border, the lid was dissected into 2 layers almost to the tarsal border. Into this was inserted a thin band of preserved costal cartilage to serve as an armature. This was possibly 12 millimeters wide and 18 millimeters long; its 3 centimeter wide base was sutured to the orbital border below with No. 000 silk, and the knife-like upper edge was fitted into the newly made lid slit and sutured so as to hold the lid border at its proper level. This established contact between the globe and tarsal border except just at the lower punctum. The latter was subsequently brought into contact by excising a prism-shaped piece of mucosa and tarsus from just below and by suturing the defect. Figure 3a shows the condition before implantation of the cartilage and Figure 3b the result. The fullness of the upper lid is edema following recent operation.

This plan is appropriate for an occasional case, but its execution presents certain inherent technical difficulties. It can be done with live, autocostal cartilage better than with the preserved. At the junction of the eighth and ninth cartilages, one can usually find a rather flat area from which a thin layer of both cartilage and perichrondrium can be shaved. If this is the white cartilage of the young person, this would tend to curl with the concavity on the perichondrial surface. This can be released by cuts through the perichondrium, but a certain amount of bend is desirable to correspond to the forward bulge of the lid. Yellow cartilage does not curl so much. We have used 2 short pieces of yellow cartilage, side by side, but we found it difficult to prevent the line of contact from being visible on the surface. The plan is also open to the objection that it gives a fullness rather than a transverse hollow at the base of the lid, but that can be the lesser of 2 evils.

Case 4. Traumatic paralysis—ectropion at inner canthus. The patient had partial paralysis of upper lip, ala, and lower eyelid with some sagging of the lid away from the globe, especially on its inner half (Fig. 4a). The paralyzed upper lip and drooping ala were raised with fascia strips, and a flap from upper lid, base toward nose, was switched into an incision just below the tarsus of the lower lid in an attempt to hold the lid up and against the globe. This latter was but partially successful. Five months later a fascia strip was passed hammock-wise through the lower lid; the outer end was fastened in the outer part of the occipitofrontalis muscle of the opposite side. This has maintained contact of the tarsus with the globe. In addition, a surgical adhesion was made between the upper and lower borders of the inner canthus but without obliterating the natural skin border of the canthus. The normal drainage of the tears through the puncta has been re-established (Fig. 4b).

Case 5. Total paralysis of the right side of the face from peripheral nerve destruction. The face tissues were extremely flaccid and drooping on this side and there was an ectropion of the lower lid with overactivity of the levator palpebræ muscle (Fig. 5a and b). The face tissues were raised and held in this position by loops of fascia anchored above which took the strain of their weight from the lower lid. The outer fifth of the flaccid lower lid was excised, a canthoplasty was done in addition, and also a transverse elliptical excision of the overhanging excess skin of the upper lid. This gave a fairly satisfactory result with a good contact of the tarsus, and the man can close his eye almost completely (Fig. 5c and d).

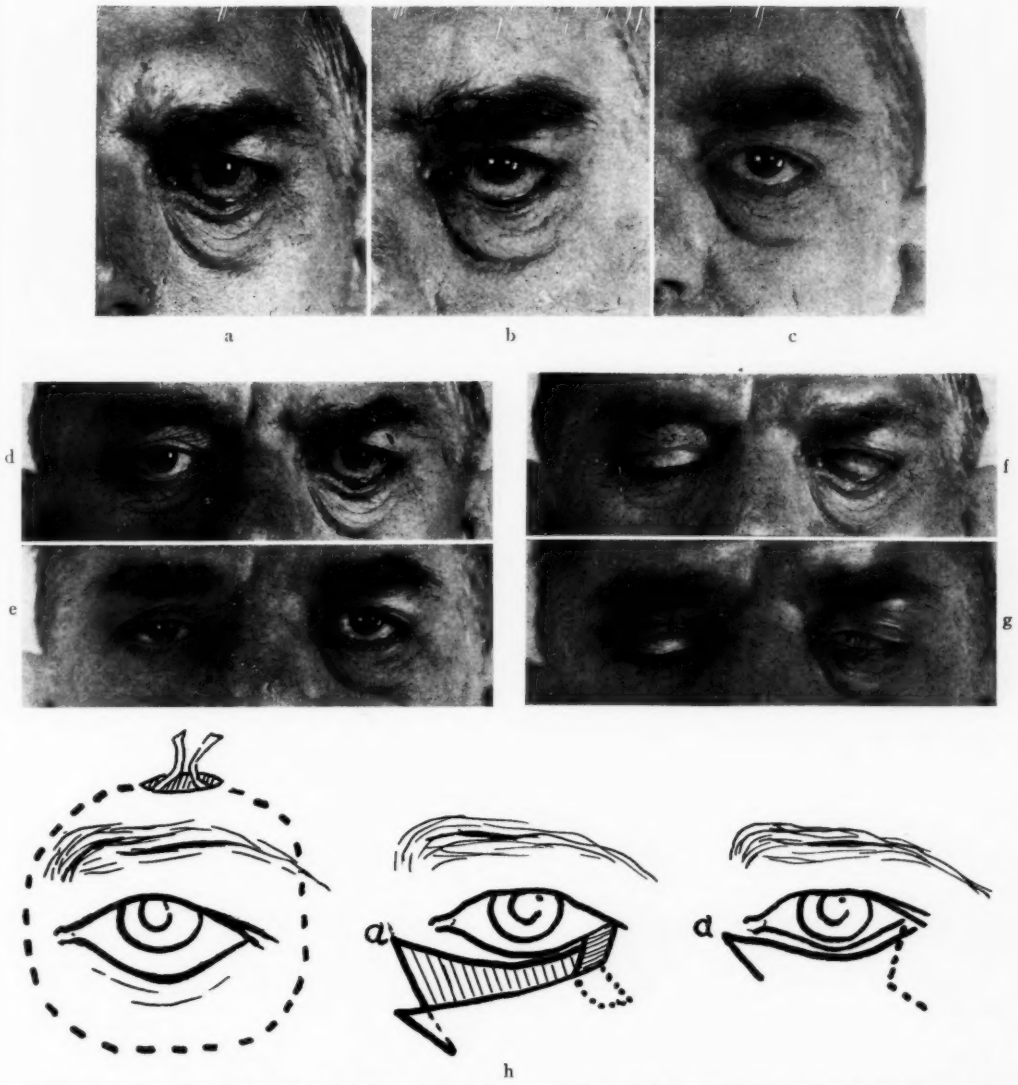
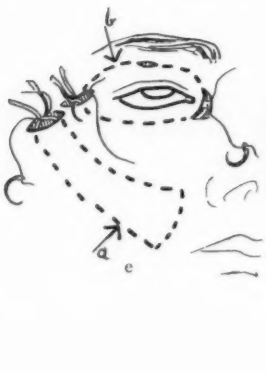


Fig. 6. Case 6. Total paralysis of left side of face following removal of a parotid tumor. a, b, and c, Show how and what was accomplished first by tendon loops alone and then by plastic operation on the lid. d and e, Show a comparison of the pre-operative and postoperative results with the normal open eye. f and g, Show a comparison of the pre-operative and postoperative results with normal closed eye. h, Diagram of operative procedure.

CASE 6. Total paralysis of the left side of the face following removal of a parotid tumor. This was done 5 years previous to our first examination. For its correction the tissues of the left side of the face were first lifted and tightened after the plan used in Case 7, but with wider removal of the skin at the hairline. At this time a strip of fascia was made to traverse the base of the lower lid, and the 2 ends were passed subcutaneously upward, one internal to the inner canthus and the other external to the outer canthus, encircling the orbit and brow by traversing the lower part of the occipitofrontalis muscle (Fig. 6a). The loop was closed by suturing the 2 ends together with fine

a c

b d



e

Fig. 7. Case 7. Total paralysis of right side of face following removal of acoustic nerve tumor. a, Shows the pre-operative condition with eyes open; b, shows attempted closure of eye before operation; c and d, postoperative result; e, diagram of operative procedure.

a b c

Fig. 8. Case 8. Destruction of trunk of seventh nerve within temporal bone. a, Shows condition at time of first examination; b, illustrates what was attained by lifting side of face with fascial strips and putting one circumferentia strip around the palpebral fissure; c, shows result 1 year after anastomosis.

silk, after making and estimating the desired tension (Fig. 7e). This corrected the sagging lid only partially which was not only particularly annoying on account of appearance and discomfort, but the constant tearing was embarrassing in the patient's work as a physician. This plan of using the circumferential fascia strip differed somewhat from that used in Cases 7 and 8, and was not as effectual. However, here we had to deal with a much greater relaxation of the lid than in either of the 2 others. Three years later a tightening operation was done on the lower lid as follows (Fig. 6a): A skin incision was made, starting at point *a*, internal and above the inner canthus, running across the lower lid just beneath the lashes, skirting the outer canthus, and going 1 centimeter beyond. A second skin incision, starting at *a* divided the skin down to the orbital border, and this skin flap was undermined. A "dog-leg" excision was made from the outer extremity of the tarsal border and lining tissues of the lower lid and this defect was closed by suture. The skin flap was shortened by removing a wedge from the inner end and the defect was closed by suturing, as was also the incision below the lashes (Fig. 6b and c).[1]

Figures 6a, b, and c with diagrams show how and what was accomplished first by the tendon loops alone and then by the plastic operation on the lid. Figures 6d and e show a comparison of the pre-operative and postoperative results with the normal open eye. Figures 6f and g show a comparison of the pre-operative and postoperative results with the normal closed eye. The final photograph was taken 2 years after the lower lid adjustment, but since then there has been considerable stretching with corresponding droop of the lid and it is our intention to implant a shell of cartilage, as shown in Figure 3.

Case 7. Total paralysis of the right side of the face following removal of an acoustic nerve tumor 12 years previously. The face distortion was corrected by implantations of fascial strips which engaged the apponent muscles of the opposite side, while the cheek was supported by a loop that engaged the buccal labial fold. These were fastened above and laterally in the parotid and temporal fascia with fine silk sutures. At the same operation a wide crescentic excision was made of the excess skin and tissue in front of the ear and in the hair line. The borders of the defect were approximated with fine buried silk. The sag of the lower lid and the over action of the levator palpebræ muscle were much improved by the use of a circumferential strip of fascia lata. An incision was made 1 centimeter behind the external canthus down to the fixed tissue; also a semilunar incision around the internal canthus exposed the inner palpebral ligament. Through the external incision, a "surgical" (curved) needle carrying a fascia strip was made to traverse the upper lid, coming out at the middle of the lid near its upper border, and re-entering, emerging through the semilunar incision mesial to the internal canthus. Where this strip crossed the internal palpebral ligament, it was attached to the latter with 2 loops of silk suture, but these loops were not tied at this time. The fascia-carrying needle was then made to encircle the lower lid and to emerge through the lateral incision. The sutures at the internal palpebral ligament were tied and the upper strand of fascia was attached externally at the outer canthus with enough tension partially to restrain the levator palpebræ muscle. Then the 2 ends of fascia were sutured together and fastened in the usual manner with several fine silk sutures with enough fascia tension to give proper support to the lid (Fig. 7e). Figure 7a shows the pre-operative condition with eyes open. Figure 7b shows the final result. Note the decreased vertical width of the fissure. Figure 7c shows attempted closure of the eye before operation. Figure 7d shows the postoperative result which was obtained by operation.

A study of these photographs suggests the possibility that a still better result might have been obtained if the lower loop had been placed a little higher in the lower lid and had also been drawn a little tighter.

Case 8. Destruction of the trunk of the seventh nerve within the temporal bone 15 months previously. Figure 8a shows the condition at our first examination; the whole of that side of the face was paralyzed completely. Figure 8b shows what was attained by lifting that side of the face with fascial strips and putting one circumferential strip around the palpebral fissure, as was done later in Case 7, except that careful anchorage of the fascia just mesial to the inner canthus was omitted. Previously we had made an anastomosis of the cut seventh nerve to the spinal accessory nerve and the fascial loops were used to raise and fix the paralyzed tissue to get immediate improvement on account of the mental state of the patient. The latter somewhat lessened the vertical height of the fissure as is shown by comparing Figure 8b with 8a. Figure 8c, taken 1 year after the anastomosis, shows the further improvement that resulted from the re-innervation of the face muscles. The slight vertical ridge shown between the nose and the internal canthus marks the course of the fascia which has drawn slightly away from the periosteum. This ridge might even now be eliminated by excising a bit of the fascia loop.

[1]This operation was done in May, 1937, and is somewhat of an exaggeration of the ideas presented by Dr. John W. Wheeler at the Second Congress of the Pan-Pacific Surgical Association, 1936, and published in their Proceedings, pp. 228–229, and also in the "Collected Papers of John Martin Wheeler," pp. 338–342, entitled "Halving Wounds in Facial Plastic Surgery."

SCLERAL SCARS AND GRAFTS

Certain binding scars situated within the conjunctival sac can compromise normal vision by limiting proper lid clearance or free movements of the globe, and in addition may cause actual discomfort. These are most commonly caused by chemical burns, lye in children, and often thrown or splattered acid in adults, while trauma or infections will account for a few. These scars usually represent a much greater loss of conjunctiva than the area that has closed the defect. For the surgical correction of symptoms, not only must the limiting scar be divided or removed, but the loss must be remedied, either by conjunctival shifting or by the implantation of free grafts. We, personally, have had no experience with free grafts of mucous membrane, for 5 reasons: (1) They must of necessity be relatively small because of the scarcity of available material to draw from. (2) Our experience with skin grafts leads us to believe that a homomucous graft would not remain permanently, except in identical twins. (3) Free skin grafts of any size are easily and quickly obtainable. (4) In replacing large losses from the oral mucosa with free skin grafts, we have had very few failures of the graft to "take," and almost no complaints about the final result when the graft had been sufficiently large. We have had similar experience in enlarging eye sockets or releasing the lids to facilitate better fitting of an artificial eye. We have had quite a number of the latter come in for re-operation—our own or the other fellow's—and the fault has usually been a matter of the quantity not of the quality or the position of the graft already implanted. (5) In cases in which it is practical we have avoided placing a skin graft in apposition to the cornea, but the late John Wheeler felt that it is a safe procedure.

A free, autoskin graft placed in the socket will for a time exfoliate, give off an excess of sebaceous discharge, and may also apparently irritate adjoining normal conjunctiva into excessive mucus secretion; but given a socket of proper shape, a comfortably fitting eye, sufficient lining, and a reasonable postoperative recovery period, I think there will be few instances in which the skin-lined socket will not prove relatively, if not quite, satisfactory. However, when all or nearly all of the normal mucous lining has been replaced by skin, dryness of the empty socket has proved somewhat annoying.

Based on the observations and experiences cited, we were, when confronted with a case of a lower lid fixed by scar to the lower half of the sclera and cornea, emboldened to free the globe and substitute a split skin graft for the lacking mucosa both of the lid and of the sclera (Fig. 9). This is but another application of the "outlay" graft contrived by Gillies, Waldron, and their Sidcup Hospital associates as a substitute for an Esser "inlay" graft in replacing burn losses of skin of the eyelids. The use of this same plan within the mouth was just a step, and from thence to the empty eye socket was but another. If a patient is in good condition, asepsis is present, and hemorrhage has been controlled, the proper set of the graft will depend largely upon the tension with which the tissues are drawn around a graft-covered form of wax or other material that snugly fits into the sulcus to be lined or against the raw surface to be covered. With careful consideration of the conditions found in the damaged mouth, this is not ordinarily a very difficult matter to one familiar with the use of skin grafts; when, however, a graft is to be applied to a seeing eye, the technique is far from simple, and the possibilities of grief much greater. In the first place, all the precautions and safeguards that accumulated ophthalmological experience demands in undertaking any operation within the con-

a b c

Fig. 9. Case 9. Lye burn obliteration of lower sulcus. a, Outer three-quarters of lower half of conjunctival sac obliterated; lower lid was attached as high as middle of cornea and globe almost completely fixed. b, Stab wound at bottom of sulcus for rubber dam drain. c, Slight area at border of center of lower lid not covered with graft.

junctival sac must be exercised here in addition to the complexities inherent to an operation that, if done in any other part of the body, would be classed as a general surgical procedure. In incising or removing scars, the damaged sclera must not be punctured, the outlets of the lacrimal gland ducts should not be obliterated, and the attachment of the recti and oblique muscles must be respected.

Above all, the cornea is the greatest source of concern. In the whole course of the operation, it should not be touched by a gauze sponge, and even quite wet cotton or the gloved finger is not free from objection; also, the cornea should never be allowed to dry. This drying is prevented in ordinary ophthalmological operations by frequent or constant bathing with saline solution from a dropper. This latter procedure might not be best for implantation of the graft, but consideration of the cornea should come first; it is an avascular structure which has little resistance to pressure and the normal lining of the normal upper eyelid is its accustomed and safest contact. In the dissection, the scar should not be removed from the cornea at this time; it can be done more safely later; nor should one dissect too closely to the sclera as the full thickness of this wall might have been burnt through in places. However, lumpy or fringed scar projections should be shaved off smoothly before the graft is applied. To avoid harmful, uneven pressure on a denuded sclera that might be quite thin in places, one may choose for the supporting form a soft padding material, such as damp cotton, or some sort of pliable wax that will hold its given shape but will, at body temperature, also further adapt its form to that of the contacting tissues. We have used cotton in several instances, and in others paraffin that can be molded when submerged in water warm enough to be comfortably borne by the hand.

Our experience, which is here presented not without considerable diffidence, is limited to 8 scleral grafting operations on 6 different eyes. Though the graft "took" in every instance, still the postoperative course of each of these operations was complicated by a corneal irritation, or an ultimately controlled ulcer occurred in half of them. However, I now believe that this occurrence was due to technical errors and was not essential to the method. This conclusion is based upon a recheck of circumstances and occurrences related to these 8 operations, and this recheck also fosters a conviction that risk of occurrence would be lessened, or the extent and depth of the ulceration would be more easily controlled, if the following precautions were adopted: (1) Each step of the whole operation, whether done in one or several stages, should, as far as possible, be foreseen and individually planned, and the sequence of procedure decided before the operation is started. It will go far to insure final success of the whole procedure to have the individual steps carried out smoothly and in proper sequence. (2) A paraffin form rather than cotton should be used when the raw area to be grafted is in close proximity to the cornea. A certain amount of excess skin is necessary in fitting the graft to the form, but that part of the graft not in direct contact with a raw surface quickly macerates, because it is in a bath of warm tears. This will soon allow the cotton to break through the restraining, nonattached part of the graft and it might come into contact with the cornea. (3) The form supporting the graft, whether cotton or wax, should be removed early, allowing it to remain in place 2 or possibly 3 days at the longest. A "taking" graft will have a blood supply, and will be adherent to its new bed within 24 hours. Upon removal of the form or stent,[1] one should be able, with an anesthetic, local or general if need be, to trim the unattached excess graft right up to the limit of the grafted area. Maceration quickly changes to putrefaction, but early removal of the form or "stent" makes possible the elimination of these potential corneal irritants. (4) After 1 or 2 days, the conjunctival sac may be irrigated cautiously with normal saline solution or any indicated medicant. If a drug will not injure the eye, it is not likely to injure the graft.

It should be borne in mind that not all these recommendations are based on the authority of direct observation; some are deductions drawn from reconsiderations of the circumstances of disaster.

In dissecting deeply alongside the globe, the attachments of the ocular muscles must be avoided, but this sulcus should be made deep enough to allow the orbital fat to present within its depth. When this occurs, it not only means that the adhesions have been divided, but also that adherence of the fornix of the infolded graft adhering to this ring or arc of fat will permit some mobility of the globe. This movement may be slight at first, but with just a little play established it will gradually increase as the result of the activity of extrinsic eye muscles. On theoretical grounds, one might expect that as subsequent contraction of the graft lessens the depth of the sulcus, the forward movement of the fornix

[1]The word, "stent," was coined among the British, possibly at Sidcup Hospital, to designate the graft-carrying form, named after the man who made the dental modeling compound that they first used with their "outlay" grafts.

Fig. 10. Case 10. Scar fixation from trauma and infection. a and b, left, Show lack of voluntary downward or outward movements of the globe; c, right above, liberation of the globe and lids at the inner canthus; d, fixed globe and a short transwidth of the fissure in spite of an increased distance between the canthi.

will draw the fat further forward on the globe. Conversely, if this fat ring cannot be demonstrated, I should think the ultimate amount of glove movement would be more problematical.

Better to avoid uneven or irregular pressure on the sclera and to obtain wider contact of the graft with the orbital fat at the depth of a newly made fornix, a built-up form of moist cotton would appear more practical than one of molded wax for the upper, inner, and outer fornices. In the upper, lateral, and mesial fornices, pledgets cut from pressed, flat layers of moist absorbent cotton are rather convenient. These are put, one at a time, into the sulcus depth, but each piece should smoothly join or overlap its neighbors and it is better that each individual piece be so placed that its proximal edge remains easily accessible for convenience and surety of its removal. In the lower fornix, a downward dissection to the floor of the orbit should expose the orbital fat, and here a carefully molded paraffin shell may be quite appropriate.

One may have a choice as to whether the attempt will be made, in eliminating a widespread scar, to do the work in one or several steps. But no matter what is decided, depth of the new sulcus should include a wider arc on the globe's circumference than did the actual adhesion. By incising the musosa of the fornix beyond the original scar on each side, the graft can be made to overlap the normal mucosa, which tends to prevent the formation of a plica of scar or mucosa when the natural mucous-lined sulcus joins the new skin-lined sulcus.

It is desirable that the lids be closed over the cornea, and it is usually safer to hold them in gentle contact by means of 2 sutures, placed not through the tarsal border but so that each loop will catch in the skin immediately beyond the lashes and tied so as not to invert the latter. Over the sutured lids, a cotton pad and a moist marine sponge, held with gentle pressure, is the correct dressing. If the lids cannot be closed, the tarsal fissure can be filled with vaseline and covered with a watch crystal, or with a built-up cup of damp, pressed layers of absorbent cotton, as devised by Wheeler for dressing his patients who have had ptosis operations performed.

For a few days both eyes should be kept covered to limit movement. Barring indications to the contrary, the first dressing is left undisturbed until it is desired to give the eye some sort of attention; and in the first few hours after operation, anodyne may be given, but on the development of real discomfort or pain, the outer dressings are removed and if this does not give relief, the sutures also in order that the cornea can be viewed and perhaps treated.

All these patients have, so far, with the help and counsel of ophthalmological service, made a good postoperative recovery, but as to the ultimate behavior of the graft or the orbital tissues we can but surmise. We have lost track of our 2 oldest cases of scleral grafts, but have followed another for 6 years without evidence of change or disturbance. Dr. Meyer Wiener has for 20 years been implanting a small skin graft right next to the cornea for control of recurrent pterygium and has never seen any sign of corneal reaction from its presence. A rough scar or linear fold of graft can cause irritation, and we have excised these by a longitudinal incision, or of any pattern most suitable, and have allowed the defect to heal over naturally.

A fixed globe is incompatible with binocular vision, a fixed lid no better, and when such cases have come to us we have attempted to do something for their relief.

Case 9. Lye burn obliteration of lower sulcus. A 4 year old child had spilled powdered lye into the right conjunctival sac 3 years previously. The outer three-fourths of the lower half of the conjunctival sac was entirely obliterated; the lower lid was attached as high as the middle of the cornea and the globe was almost completely fixed (Fig. 9a).

At the first operation the lower lid was freed from the globe on the right side by knife dissection to a depth of 2 centimeters and an outer canthotomy was done for better access. The orbital fat appeared at the bottom of the sulcus. A rubber dam drain was placed through a stab wound at

Fig. 11. Case. 11. Loss and subsequent scarring from thrown acid. a, left, Results of a thrown acid burn which completely destroyed the lower lid and the skin of the cheek below this, the skin of the forehead, the eyebrow, and the skin covering the upper lid. b, Showing patient with shell eye over globe which was almost intact.

the bottom of the sulcus (Fig. 9b). A shell stent of paraffin was carefully molded to fit the surface of the globe accurately. Over this was draped a thin graft cut from the inner surface of the right arm and then slipped into place. The external canthus was then closed and the lids sutured together with 2 silk sutures, and both eyes were bandaged. Because of the age of the child, chloroform was given 6 days later for the removal of the stent. The cornea was found cloudy, but was seen by Dr. Shahan who said no damage had been done. There was failure of the graft to adhere to the sclera for a distance of 2 millimeters below the upper line of incision. There was also a web of scar rising up between the natural inner mucous lined portion of the sulcus, and the newly grafted pocket. There was a very slight area just at the border of the center of the lower lid 2 by 4 millimeters which was not covered with graft (Fig. 9c). The new pocket was about 18 millimeters deep and the canthotomy had permitted it to be quite wide. If one allows for even a 60 per cent contraction, the new graft should prove ample.

This case has been cited once before in reference to certain curious muscle reflexes that disappeared when motion was restored to the globe.[1] It happened to be our first experience in placing a skin graft on the sclera.

Case 10. Scar fixation from trauma and infection. Following a recent automobile injury the patient when first seen had a fixed outward displacement of the upper part of the maxilla and zygomatic bone, with a palpable line of fracture behind a vertical scar that extended from the inner end of the brow, through the lids, puncta, lacus, and cheek. Wounds were not in condition for radical correction at the time of the first visit.

[1] Repairs and adjustments of the eyelids. J. Am. M. Ass., Fig. 16, 1932, 99: 2171–2176.

The patient did not return until 4 years later. At that time the globe was displaced outward and the distance from the inner and outer canthi was 4 millimeters longer on the right side than on the left, due to displacement of the outer canthus; but owing to a conjunctival loss and subsequent scarring near and at the inner canthus, the length of the fissure was actually shorter than its fellow of the other eye (Fig. 10b). Incidentally, the patient apparently had no voluntary downward or outward movements of the globe and those outward and upward were quite limited. Whether this was entirely due to globe fixation or partially due to nerve injury was difficult to determine (Fig. 10a and b).

The release of the globe and lids was undertaken by an incision and a deep cleavage dissection just within the lid borders at the inner canthus; this was lined immediately with a split skin graft. A cold abscess was encountered in the scar mass but because of the absence of acute symptoms, a graft on a cotton stent was inserted into this sulcus in spite of the fact that it was partly an abscess cavity. This graft healed in place above and mesially but with some loss below. There was considerable reaction in the surrounding conjunctiva but there was no note of any corneal damage.

When the patient returned a year later, eye excursion was found considerably increased but the inner part of the lower sulcus was still missing, the tarsal border was still attached to the globe, but above, the sulcus was of normal depth. A canthotomy was done and lower sulcus re-established. This time the graft was inserted on a paraffin, shell-shaped "stent." Healing was without special incident and considerably more improvement of the eye movements followed but not sufficient to do away with all the diplopias, some of which might have been due to weak muscle power.

Figure 10d shows a fixed globe and a short transwidth of the fissure in spite of an increased distance between the canthi. Figure 10c shows liberation of the globe and the lids at the inner canthus. Figure 10d shows a still present outward displacement of the outer canthus which could be released by cutting the external ligament and some scar

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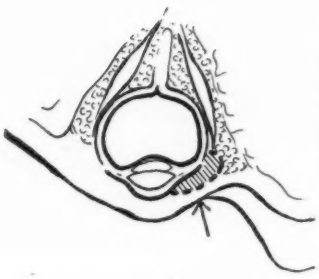


d

Fig. 12. Case 12. Lye burn of scleral and palpebral conjunctiva at inner half of conjunctival sac. a and b, Showing shallowness of both fornices; c, result after operation; d, diagram showing the bend of the "U" of the split graft in the mesial sulcus.

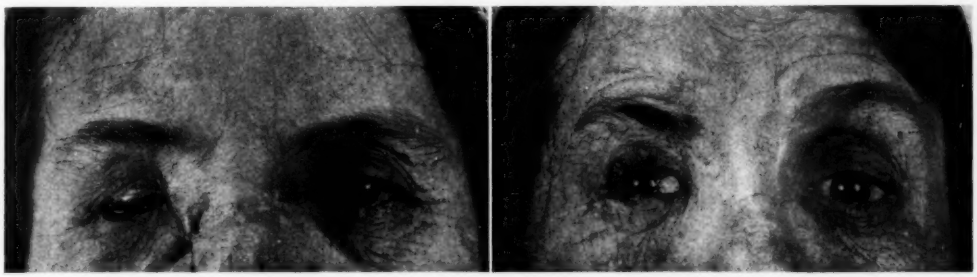
in the neighborhood. If this were done, it should be a simple matter to restore and reposition the inner end of the lower lid.

This operation should be considered incomplete because at neither sitting was the orbital fat exposed in making the new sulci. Due to uncertainty as to the essential functioning power of the inferior rectus and of the oblique muscles and since the functional result seemed fairly satisfactory, further freeing of the globe was not urged.

CASE 11. Loss and subsequent scarring from thrown acid. Figure 11a shows the results of a thrown acid burn which completely destroyed the lower lid and the skin of the cheek below this, the skin of the forehead, the eyebrow, and the skin covering the upper lid. The loss also included the conjunctiva of the lower two-thirds of the sclera and all but about the upper 2 millimeters of the cornea. The lids and brow were restored by a series of skin grafting and flap operations, and the lower sulcus by a scleral corneal graft. This permitted the patient to wear a shell eye over the almost intact globe (Fig. 11b). We had advised him to continue the use of the shell eye until an attempt could be made to give him a transparent cornea. However, he became impatient and recently returned wearing a sunken empty socket which was the result of removal of the globe. Now the socket is being reconstructed so that he can wear the formed eye.

CASE 12. The scleral and palpebral conjunctiva had been burned with lye at the inner half of the conjunctival sac 20 years previously. The loss had healed over partly by a drawing-in of the neighboring conjunctiva and partly by surface scar; there was a corresponding limitation of the globe movement and a great deal of physical discomfort. The scarring on the sclera had become epitheliated but very rough and contained the openings of several fistulas which discharged mucopus almost continually causing great inconvenience. It was thought that part of this discharge might be from the lacrimal sac. For this reason the latter was removed by Dr. Lawrence Post, who then referred the patient to us to deal with the conjunctival loss and fistulas in the scar. Cocainization did not permit of a satisfactory examination, but under a general anesthetic at the time of the first operation it was found that the fistulas led down to a large, shallow abscess cavity on the surface of the sclera. This scleral scar extended into but not to the full depth of both fornices, so that the latter were in consequence very shallow (Fig. 12a). At the same operation the whole of the anterior scar wall of the abscess cavity was removed, leaving no overhanging edges, and a dissection was made around the inner half of the globe of sufficient depth to expose the orbital fat. Into this sulcus was inserted a folded thin split skin "tent" graft, the 2 walls of which were separated by a built-up layer of moist cotton, the lids were sutured together, and both eyes covered. The patient was discharged from the hospital 5 days later. The note does not mention any particular corneal irritation, but a note made 8 days later, after almost daily packing of the newly grafted pocket with wet cotton, states that "eye quite movable; graft is perfect." The discharge which had been the cause of great complaint was reduced considerably but not entirely checked. This was disappointing and thought to be due partly to rough ridges of the remaining scar and irregularities at the junction of the graft and the conjunctiva. Seven months later these irregularities were excised from the sclera, the bordering irregular conjunctival junction lines were smoothed out, and the surfaces healed spontaneously. Following this, there was still less discharge and the patient was considerably more comfortable, but not entirely so.

As the areas already grafted had a satisfactory appearance, it was decided to deepen the upper and lower fornices which were partially obliterated by scar. This was done 1 month later, and into these was placed a thin roll of moist cotton covered with a split graft and bent to a "U" shape. This was placed into the upper and lower fornices in contact with the orbital fat; the bend of the "U" was in the mesial sulcus (Fig. 12d). It was held in place by suturing the cut edge of the palpebral conjunctiva to the scleral edge in both fornices. This permitted a rather free postoperative view of the cornea; but in spite of this an ulcer of considerable extent developed several days after operation, due most likely to a break in the macerating graft which allowed cotton to touch the cornea. This has now healed under the care of Dr. Post and Dr. Sanders, with little evidence of an increase in size of the original



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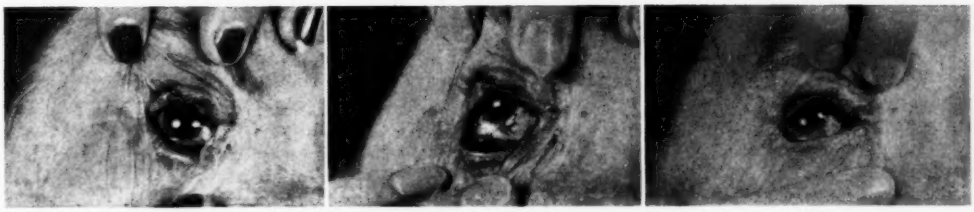

b c d

Fig. 13. Case 13. Lid destruction and scleral adhesions from glass cut and infection. a and b, Patient when first seen showing inner canthus drawn forward on the side of the nose; c, showing corneal ulcer after operation but graft satisfactory; d, lining graft sutured to bordering skin; e, the final result.

corneal scar (Fig. 12c). The patient is now comfortable and the recent ulceration has healed, leaving no increase in the original corneal scar, and while the increase in ocular movement is objectively not very evident, her previous diplopia on external rotation has been eliminated almost entirely.

Case 13. Lid destruction and scleral adhesions from glass cut and infection. In addition to extensive injuries in other parts of the face, the levator palpebræ muscle had been severed; almost all of each mesial third of both lids had been destroyed along with the corresponding parts of the palpebral and scleral conjunctiva, and while healing the inner canthus had been drawn forward on the side of the nose (Fig. 13a and b).

The missing skin of the eyelids and of the side of the nose adjacent to the canthus was restored and the canthus was eventually worked backward toward its proper position by 3 repetitions of the following procedure done with but slight variation. A vertical similunar or trapdoor incision down to the periosteum was made at the junction of the lids with the nose, and the undermining was done both toward the nasal bridge and also outward, removing all scar from the periosteum but leaving a thin layer of scar where the periosteum was missing. In this way a defect could be obtained at each sitting, into which was sutured a full thickness postaural skin graft; each suture engaged the bordering skin edge, the graft edge, and the underlying periosteum or scar. Proper lateral tension could be made on the graft and deep contact maintained by tying the suture ends over a cotton stent. An external canthotomy was done and the function of the severed levator palpebral muscle was replaced by a fascia lata loop that connected the upper tarsus with the occipitofrontalis muscle, but the newly restored inner portion of the lids and inner canthus were still adherent to the globe (Fig. 13b). These were freed by dissecting deeply and implanting a split skin graft on cotton stent. As usual, there was considerable postoperative reaction and an easily controlled corneal ulcer, but the graft proved satisfactory (Fig. 13c). The operation was completed with an internal canthotomy at which the lining graft was sutured to the bordering skin (Fig. 13d). Figure 13a shows patient when she first came to us, and Figure 13e the final result.

Since this paper was presented before the American College of Surgeons, Dr. George H. Cross of Chester, Pennsylvania, has informed us that he has successfully applied Thiersch grafts to the sclera which were held in place by a thin silver shell made for him by Pilling and Sons. Also, Dr. Charles H. May has sent us a reprint of his article "Restoration of the Conjunctival Cul-de-Sac in a Case of Total Symblepharon by Means of Thiersch Skin Grafts," which appeared in the *Archives of Ophthalmology*, 1899, 28: No. 2. He there describes a case in which he had successfully restored the conjunctival sac for the retention of an artificial eye. He used a porcelain shell such as forms the base of an artificial eye to support the grafts after the lids had been dissected free from the globe. He also relates that Dr. Chambers of Jersey City had, in a case of partial symblepharon, used an ordinary button covered with gauze to support the graft and that Dr. Chambers had reported this to the Ophthalmological Section of the New York Academy of Medicine some 2 or 3 years previously and that subsequently Dr. Marple had presented two similar cases of successful result by this method in partial symblepharon. Dr. May also cites that Morton, of Minneapolis, *Ophthalmic Record*, 1898, August, recommended the use of a prosthesis after the grafts had been inserted and held in place by a line of sutures, reporting several successful cases in which he had operated in this manner with the object of restoring the fornix for the retention of an artificial eye. Apparently, in all these cases, the lids were released to facilitate the fitting of an artificial eye.

We are indebted to certain of our ophthalmological friends who cared for ocular complications in some of these cases, most frequently to the Drs. Post and Sanders, who also read this manuscript.

BLEPHAROPTOSIS

The Technique Of Its Surgical Correction

DANIEL B. KIRBY, M.D., F.A.C.S., New York, New York

BLEPHAROPTOSIS may be defined as any drooping of either or both upper eyelids. It indicates a weakness of the levator or of the smooth muscle of the upper lid. The weakness of the levator and smooth muscle may be (1) local in origin as, for example, by trachomatous infiltration; (2) it may be due to muscle degeneration as in progressive muscular atrophy; (3) it may be due to peripheral, or (4) central nervous disorders. The conditions of mechanical interference with the action of the upper eyelid, as for example by inflammatory or scar tissue or by tumor formation, are beyond the scope of this paper and will not be considered here.

The need for surgical correction of blepharoptosis. The need for the operation may be the uncovering of the pupil as in a congenital case to permit the function of the eye to develop, or it may be the correction of a faulty head position and facial distortion in either a congenital or acquired condition. The decision to operate upon a patient with blepharoptosis will depend upon the general condition of the patient, the question of whether or not the cause of the drooping eyelid is inactive, and upon the condition of the lids and eyes.

Pre-operative examination. The pre-operative data required for the choice of the proper technique to be employed in the individual case are: (1) The vertical width of the palpebral fissure with eyes level, with eyes elevated, and with eyes depressed. Photographs should be taken in these 3 positions. The measurements should be compared with those of the patient when employing the aid of the frontalis muscles, arching his brows, corrugating his forehead, with the head thrown back, and also with the head level and the brows depressed by the fingers of the observer. The latter measurements give the index of the true strength of elevator power of the muscles of the upper eyelids when acting alone. (2) The horizontal width of the palpebral fissure as measured from the angle of the internal canthus to that of the external canthus by tangent and marginal measurements. (3) Exophthalmometer reading. (4) The sensitivity of and the ability of the cornea to withstand exposure. (5) The effect of cocaine on the smooth muscle of the lid.

From the Department of Ophthalmology of the College of Physicians and Surgeons, Columbia University, and the Institute of Ophthalmology, Presbyterian Hospital.

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ANALYSIS OF REPORTED TECHNIQUE AND PROCEDURES

The multiplicity of techniques for the surgical correction of ptosis is an indication of the unsatisfactory results which follow the best efforts in the hands of the most accomplished and experienced surgeons. Nearly everyone has tried to improve on the published techniques. No one surgeon has the opportunity to do many operations for this condition as it is relatively rare. It will be illuminating to consider the various operations by grouping them not under the names of the surgeons connected with them, but under the specific class within which the operation falls.

1. *The removal of skin or of full thickness of the eyelid* and the creation of cicatricial bands which by their contraction pull up the lid. The removal of skin is indicated when it is redundant as in blepharochalasis, but the production of lagophthalmos and exposure of the cornea is contraindicated. The removal of a portion of the thickened tarsus is indicated in trachoma although this opinion may need modification. Sulfanilamide should be used before resorting to surgery.

2. *The natural method of improvement of function of the levator and smooth muscle* where partial function remains. This gives the most satisfactory results and should be employed whenever it is possible to get sufficient effect. It may be accomplished by resection of the tarsus and resection or advancement of the levator and smooth muscle. The approach through the skin or through the conjunctiva is used. The direct indication for these procedures exists when the muscles show partial function particularly with the brows held down and when under these conditions the palpebral fissure is wider on upward than on downward gaze.

3. *The transplantation of the superior rectus muscle from the globe to the lid permitting the use of the elevating power of the superior rectus and inferior oblique* when the levator and smooth muscles are almost or entirely inactive. It will be indicated

when the palpebral fissure is actually narrower on upward than on downward gaze. This phenomenon is produced by the movements of the lower lid on the excursions of the eye while the upper lid remains inactive. The question of whether or not this procedure should be used only when the superior rectus is strong has been debated a great deal. In the opinion of the author it may be done even when the superior rectus is completely paralyzed, provided the inferior oblique is active and strong and there is no hypotropia. If the superior oblique is also paralyzed, the condition of paralysis of elevation exists which is probably central in origin and which requires separate consideration.

4. *The procedures for the correction of paralysis of elevation* are complicated as there remains no normal elevating power. The immediate use of the frontalis to elevate the lid is contra-indicated as this would only expose the eye in a useless position of hypotropia. Wheeler made use of advancement of the inert tissues of the inferior oblique over the orbital margin and of the superior rectus on the globe and of a union of lid and globe. The palpebral fissure will not be wide; usually only part of the pupil is exposed and the orbicularis is sufficient to effect the protective closure of the lids. After the globe has been lifted from its position of hypotropia the union of the frontalis muscle may well be applied to elevate the eyelid. It might be possible in third nerve paralysis to detach the superior oblique from the globe, free it from its trochlea and after shortening it reattach it to the globe and lid for elevating power. Wiener has employed this procedure for replacing the function of the internal rectus but I have never seen it used for elevation.

5. *The employment or enhancement of the vicarious action of the frontalis muscle* may be had by uniting this muscle to the tissues of the upper lid by various means. The presence of facial distortion in ptosis by frontalis action is to be avoided. The pull of the frontalis is straight up and not a normal roll-back over the convexity of the globe.

With this analysis of the principles involved in the surgical correction of ptosis we may proceed to the consideration of the techniques which have proved satisfactory for certain purposes in the hands of the author.

TECHNIQUES OF VARIOUS PROCEDURES ADVOCATED BY THE AUTHOR

1. *The removal of skin* is indicated when it is redundant and falling down in folds as in blepharochalasis. Large pieces of normal skin have been removed from the upper lids of patients for use as free grafts without production of any permanent shortening of the upper lid and with no lagophthalmos. It is my opinion that in the average case of ptosis there is no point in the removal of skin as this skin is usually not in excess. If the skin is made adherent in the position of the normal crease, the apparent redundancy will disappear and a useful purpose will have been served. The procedure will be directly indicated in the Mongolian type of eyelid where there is no crease and where the skin pushes down over the lid margin and the lashes.

No special description need be given concerning this procedure of removing redundant skin. The area to be removed is carefully estimated and marked out and is usually found to be elliptical. Incisions which are kept within the thin skin of the lid heal gracefully without scar formation. The incisions must not be carried too far nasally because of the danger of formation of cicatricial epicanthus. There should be no lagophthalmos at the completion of this operation as no effort should be made to correct real ptosis due to weakness of the levator or smooth muscles of the lid by the removal of skin alone. The removal of normal subcutaneous tissue, the production of deep scars or bands of contraction by traumatic surgery, infection or deep sutures so that the upper lid is joined to the brow, do not constitute good surgery. The lagophthalmos due to ankyloblepharon or ectropion which may result will prove very undesirable. The through-and-through resection of skin, subcutaneous tissue, muscle, and conjunctiva, as for example by the method of de Grandemont, is radical surgery. As much as is necessary might well be accomplished in a suitable case by resection of the muscle, tendon, and tarsal tissues.

2. *The use of the vicarious action of the frontalis muscle.* The author has never been in favor of the employment of this principle in ptosis surgery because it only enhances the undesirable characteristic facies of ptosis and leads to a straight upward pull of the upper lid. The implantation of foreign material, deep long sutures, wire, kangaroo tendon, fascia lata, the burial of dermis and epidermis, I believe, are all contra-indicated. If I were to advocate any use of the frontalis, I would do it by the Reese (18) method, which entails a union of strips of orbicularis to the frontalis. There may be a place for this operation in which all the normal elevators of the globe and lid are paralyzed.

3. *The resection of the tarsus and resection and advancement of the levator and smooth muscle of*

Fig. 1. Congenital ptosis with epicanthus.

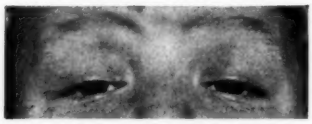


Fig. 2. Congenital ptosis without epicanthus.

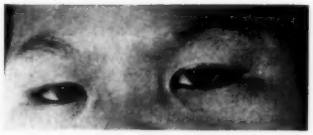


Fig. 3. Ptosis with Mongolian fold.

Fig. 4. Ptosis due to paralysis of third nerve.

Fig. 5. Ptosis caused by hyperthyroidism.

Fig. 6. Ptosis in progressive, muscular atrophy.

the lid. It seems logical and natural in cases of partial ptosis to enhance the remaining function of the levator and smooth muscle of the upper lid. The principle of developing the partial function of the levator and smooth muscle was probably used for years before the first description of the exact technique by Bowman. The upper lid was everted strongly. The incision was made through the conjunctiva along the length of the superior border of the tarsus. The conjunctiva was dissected back with scissors and forceps so as to expose the tendon of the levator and superior tarsal border. Two or 3 sutures were passed through the levator about 2 centimeters back of its insertion. The muscle tissue was then resected in front of the line of sutures together with the superior border of the tarsus to which it is attached. The needles on the sutures were passed through the fresh border of the tarsus, and the levator and smooth muscles attached to their new position. The name most commonly associated with the use of this principle is that of de Blaskovics. Years before de Blaskovics published his paper, Wheeler had employed a satisfactory technique for resection of the levator through the conjunctiva and had many successful results but never published his method. The Eversbusch method of resection and advancement of the levator through the skin is interesting in some cases and the author has used it with gratifying results; but the ease of the procedure of operating through the conjunctiva, the possibility of accurate placement of sutures, the gauging of results by the extent of the tissues resected have led him to adopt a modification of Wheeler's technique. The changes described are simply differences in suture material and in the plan of the insertion of sutures. The dissection and plan of the operation is as Wheeler (24) employed it except for a single principle of advancement of the resected muscle as given to the author by A. B. Reese (17). The direct indication for the use of this procedure is in a case of ptosis in which the palpebral fissure is wider on upward than on downward gaze.

4. *Technique of resection and advancement of the levator and smooth muscle of the lid with or without resection of the tarsus.* Local anesthesia by procaine infiltration and block, a combination of avertin per rectum and local anesthesia, or better still avertin and general anesthesia may be used. The usual skin and conjunctival preparations are employed.

The degree of partial ptosis has been recorded and it is estimated roughly that for each millimeter of ptosis to be corrected 1 millimeter of tarsus or 2 millimeters of muscle tissue will be resected. For example with a normal right palpebral fissure of 10 millimeters and a left ptosis of 6 millimeters, the left palpebral fissure being 4 millimeters wide vertically, the desired correction should be 6 millimeters of improvement in elevation of the left upper lid. This might be accomplished by resecting the left tarsus 3 millimeters and the levator and smooth muscle 6 millimeters figuring 1 millimeter of tarsus and 2 millimeters of levator and smooth muscle for each millimeter of ptosis correction. It will probably be found that it is best to be generous and to do a little more than this, because the tissues are stretched by the application of the everting lid clamp. In general, however, if there is no stripping of muscular fibers and no opening or loss of sutures, the correction given will be adequate. It is important not to include in the suturing any firm inelastic tissue such as the fixed tarso-orbital septum.

Fig. 7

Fig. 8

Fig. 9

Fig. 7. Ptosis due to heavy tarsus of right eye. Resection of tarsus indicated.

Fig. 8. Eyes level; ptosis of 3.5 to 4 millimeters.

Fig. 9. Eyes up; palpebral fissure wider than with eyes down. Direct indication for resection of levator and smooth muscle of the lid.

Fig. 10, left. Eyes down; palpebral fissure narrower than with eyes up.
Fig. 11. Result after resection of levator and smooth muscle.

The lid is everted on an Erhardt[1] lid clamp. A heavy wide tarsus will be resected more than a narrow tarsus. The division of the resection between tarsus and muscle will be made according to the tarsus and the evidence of remaining strength of the muscle.

Step 1. A curvilinear incision is made with a scalpel along the entire everted conjunctiva just at the upper border of the tarsus. A line of cleavage is quickly and easily found between the conjunctiva and the smooth muscle which is attached to the tarsus. This line is followed by sharp scissors' dissection upward; this is facilitated if the assistant will carefully lift up the edges of the conjunctiva with 2 pairs of Lester forceps[2]. The dissection is carried back to variable distances on an average of about 8 to 10 millimeters.

Step 2. A second curvilinear incision parallel to the first is then made. In some cases it is well to produce an arch which will simulate the normal arch of the lid, rising more sharply on the nasal side; the highest point is above the nasal edge of the pupil and falls off gradually on the temporal side. The second incision in the tarsus is made through to the orbicularis; the tension of the tissues causes the wound to gape and the second plane of dissection is easily found. Two pairs of forceps hold the tarsus and muscle up vertically, and the scissors follow the dissection sharply backward as far as necessary. The flat, voluntary, and smooth muscle band is well and easily shaped.

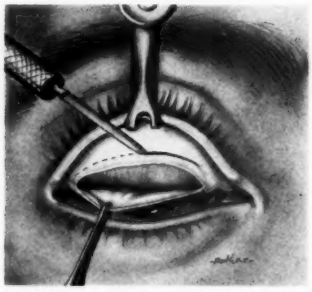
Step 3. Sutures: (a) Two double-armed No. 0000 10 day chromic catgut sutures with atraumatic needles are looped from the conjunctival side through the muscle fibers and then relooped so that the parallel muscle fibers will be cinched and not permitted to slip through the suture but still will not be strangulated. (b) Three double-armed No. 0000 silk with atraumatic needles are passed parallel through the muscle fibers from the orbicularis side and then through the conjunctiva. The catgut sutures are in the central body of the muscle and the silk sutures are arranged 1 on each side and 1 between the catgut sutures. These 5 sutures are not too many and are all important.

Step 4. The predetermined length of tarsus and muscle tissues is then removed up to the sutures by scissors' resection. Care should be taken not to cut the sutures and not to cut the parallel muscle fibers too closely to the sutures.

Step 5. The catgut strands are carried into the pouch between the tarsus and orbicularis sutures. The dense tissue on the face of the tarsus thus effects an anchoring and advancement of the cut muscle fibers as suggested by Reese. The silk strands, which are through the mucous side of the conjunctiva, are passed through the thickness of the tarsus and lid and brought out through the skin; the needles are passed through small individual rubber plates and tied. The exit through the skin will be found to vary according to the tarsus which has been resected, but usually it is about 5 millimeters above the lid margin. This protects the lashes and tends to prevent eversion of the lid margin and distortion of the lashes. It also helps with the buried catgut sutures to form the very useful crease and fold in the lid which enhances the natural appearance and action of the lid in elevation. Criticism of the number of

[1]Clamp designed by Miss Erhardt at the New York Eye and Ear Infirmary.

[2]Forceps designed by Dr. Lester, assistant surgeon, New York Eye and Ear Infirmary.



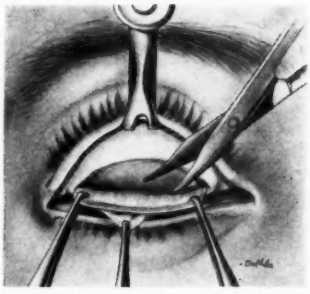


Fig. 12, left. Schematic section of the eyelid showing the levator and smooth muscles and their attachments to skin and tarsus.

Fig. 13, right, above. The upper eyelid is everted on a clamp. The first incision and dissection separate the conjunctiva from the muscles.

Fig. 14. The second incision is through the tarsus or muscle, permitting dissection of the muscles (levator and smooth muscle).

sutures employed will arise but this may be anticipated and explained; too much care cannot be exercised in preventing the slipping of parallel muscle fibers through the lines of sutures. This method develops a skin crease or fold which is so important for the life and expression of the eye.

Dressing. When this operation is performed under local anesthesia, there is no lagophthalmos because the swelling of the tissues with the infiltration of novocain and the reaction to the operation depresses the lid and masks the effect of the correction of the ptosis. If general anesthesia is used, there may be some exposure of the globe requiring a special dressing which was devised by Wheeler (24). This dressing is best described in the section devoted to the use of the superior rectus in the correction of ptosis; because after this latter procedure, it is definitely necessary to use cone-shaped dressings or conical shields which rest on the margins of the orbit, or a special suture such as Frost devised for bringing up the lower lid to cover the exposed globe.

The dressing is changed after 48 hours. The silk sutures are removed after 5 days. The immediate result in view of the edema is apt to be disappointing to the patient. It takes several weeks in some cases for the full effect to be evident. Some of the most gratifying results are obtained when this technique is applicable to the correction of partial ptosis. There should be no deformity if the incision for the resection of the tarsus is kept at least 3 millimeters and even 4 millimeters from the edge of the lid margin. In case this much tarsus is removed, the levator and smooth muscle should not be advanced into the pocket between the tarsus and skin; the possibility of everting the line of lashes by the pull of the muscles should be avoided. The best plan is to have the lifting effect distributed to the skin and to the tarsus.

5. *The transplantation of the superior rectus.* The credit for the principle of the elevating power of the superior rectus in the correction of ptosis goes to Motais (14, 15), although the names of

Parinaud and others are associated with it. The direct indication for the use of this procedure exists when in a case of ptosis the palpebral fissure is actually narrower on upward than on downward gaze.

The results, when this principle is employed, are as satisfactory as can be expected in the face of the lack of any other elevating power of the lid. The criticisms are: (1) If a narrow central tongue of muscle is attached to the upper lid, an angulation or notching will result. The use of two lateral strips of muscle from the superior rectus instead of the one central tongue has been thought of but has not been used because of the weakening of the elevator action of the globe. Care must be exercised not to produce hypotropia. The author has found that the effect of angulation of the lid may be removed by a differential or graduated tarsectomy after the result is apparent and healing is complete, and that it may in some cases also be prevented by tarsectomy at the time of the original operation. (2) If the full width of the superior rectus is attached to the lid without severing the attachment of the tendon to the globe, an unsatisfactory, inflexible symblepharon usually with entropion and districhiasis results. (3) The weakening of the superior rectus results in diplopia. This is true if the muscle is weakened too much. But if the dissection of the central tongue of muscle is accurate and confined to the central third, there will be diplopia only in the field of special action of the superior rectus. This does not prove annoying to the patient. (4) The union of the globe and the lid through the superior rectus, even though a narrow extensible tongue of muscle be employed, disturbs the co-ordination of the act of closure of the lids. The globe is prevented from rolling up normally and an effort must be made with the orbicularis to effect the closure which normally should occur through relaxation of the elevators. Thus it is observed that the palpebral fissure remains partially open during sleep and is wider on downward gaze than that of the fellow eye. No harm results from this slight exposure if the cornea is normal. These difficulties are real and not imaginary and cannot be overlooked but they are compensated for by the evident satisfactory elevation of the lid. It is true that the patient cannot elevate the lid independently of the globe, but the lid follows the globe in elevation very naturally and the expression of the eye is good. The innervation, origin, and course of the muscle fibers of the levator and superior rectus are the same so that no re-education is required for the new function of the muscle.

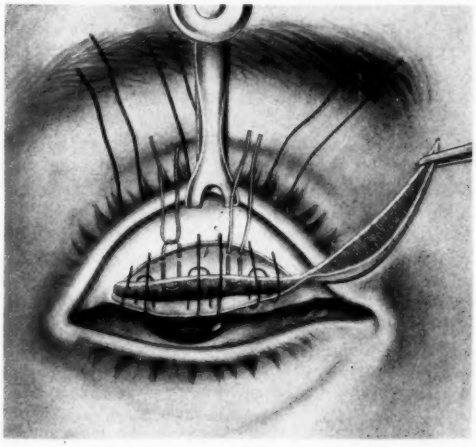


Fig. 15. The author's method of suturing in resection and advancement of levator and smooth muscles of eyelid. The lighter tone heavier material is catgut, the darker, thinner material silk. The muscle fibers are prevented from slipping by mattress sutures. The conjunctiva completely covers the muscle when tied.

Fig. 16. The catgut sutures are tied and buried on the anterior face of the tarsus. The silk sutures are brought through the skin and after they have pierced the rubber plates they are tied as shown.

6. *Technique of superior rectus transplantation.* The original Motais operation was performed entirely through the conjunctiva. The dissection was easy but the weak point in the method described by Motais consisted in inaccuracy and difficulty in the final stage of the operation, namely, that of suturing the tongue of the muscle to the anterior face of the tarsus. Shoemaker

Fig 17, left. Ptosis of left upper lid and considerable excess of skin of both upper lids.

Fig. 18. Result after resection of levator and smooth muscle. The redundant skin of the lids was untouched.

Fig. 19, left. Ptosis developing after chalazion operation. Resection and re-attachment of levator and smooth muscle of the lid indicated.

Fig. 20. Result after resection and re-attachment of levator and smooth muscle of the lid.

recognized this difficulty and published a report of some cases in which he combined the ease of finding the superior rectus and the shaping of the central tongue of the muscle through a conjunctival incision with the accuracy of suturing the tongue to the tarsus through a skin incision. The method of Shoemaker has been followed with success by a number of surgeons in this country. It was while teaching the Shoemaker procedure on the cadaver in 1927 that the author (13) discovered he could do the entire operation through the skin. This method eliminated the conjunctival incision and sutures and the necessity for removing them; it simplified the operation by reducing the number of steps even though it made the dissection more difficult. The matter of locating the superior rectus through a skin incision is decidedly more difficult than it is through a conjunctival incision but it is much more interesting and instructive. More than 10 years after publication of the technique, the author has had no occasion to change the essential original technique and uses it whenever it is desirable to employ a central tongue of muscle from the superior rectus.

The technique as described in 1928 is as follows: Local or general anesthesia may be used. A horizontal incision 25 millimeters long is made through the skin and orbicularis to the tarsus 8 millimeters above the lid margin. The aponeurosis of the levator is followed backward to 8 millimeters above the tarsal border. Here a horizontal incision is made through the levator and smooth muscle of the upper lid exposing Tenon's capsule. The conjunctiva of the fornix is held down out of the way by a retraction suture. An opening is made in Tenon's capsule at the temporal side of the superior rectus muscle and a hook is slipped beneath the muscle. The latter is exposed so that a tongue of muscle and tendon 4 millimeters wide by 10 millimeters long can be fashioned. De Wecker scissors are suitable for this purpose. A double armed silk suture is passed through 2 millimeters from the end of the tongue of muscle and tendon. The muscle slip is transplanted to a pouch which is prepared for it anterior to the tarsus. The needles are passed downward piercing the lid margin just nasal to the center of the cornea and the suture is tied drawing the muscle tongue and lifting the lid to the position which is required to get the desired effect.

A second suture is used to support the first and to secure accurate and firm apposition to the tarsus. The levator is not necessarily reunited. Excess tissue may be resected. The skin below the incision should be smoothed out in the tarsus and sutured to the epitarsal tissue to help produce a crease or fold. The skin incision is closed by interrupted sutures and a protective dressing is applied. Sutures are removed in 5 to 7 days.

The dressing to be applied is very important in order to protect the exposed cornea. The conical shaped dressing of Wheeler is excellent for the purpose. It is described as follows:

"Injury to the partially exposed cornea after operation must be avoided. The dressing should be such that the cornea is properly protected. For several years I have used a special dressing on account of lagophthalmos after the Motais type of operation, and this dressing can be recommended. A thin layer of absorbent cotton is dipped in warm water and then pressed almost dry between the palms of the hands. This is shaped to make a small cone

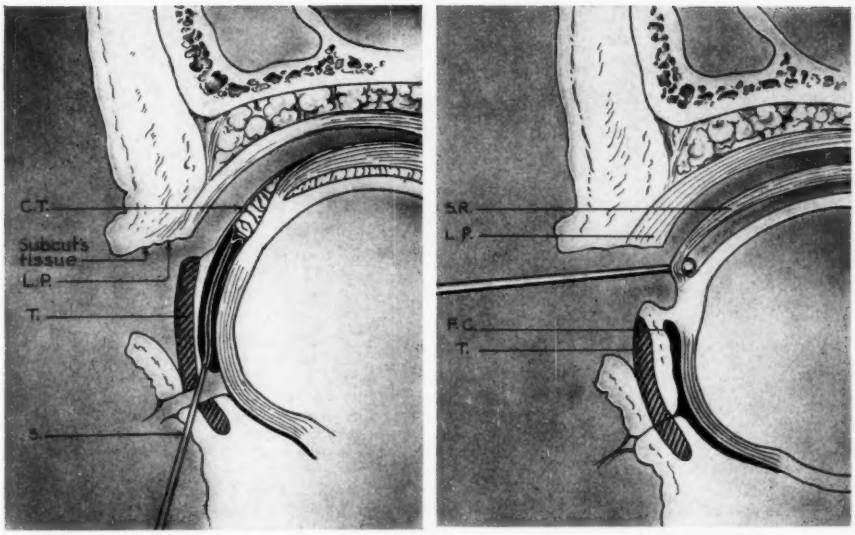


Fig. 21. Schematic drawing of surgical anatomy involved in the dissection and isolation of the superior rectus muscle. *C. T.*, Tenon's capsule; *L. P.*, levator muscle; *T*, tarsus; *S*, sutures used to retract conjunctiva at fornix and to hold eyeball down; *F.C.*, fornix of the conjunctival sac. *S.R.*, Superior rectus muscle; *L.P.*, levator palpebral superioris.

with the base large enough to cover the base of the orbit. The cone is filled with sterile petrolatum and placed over the eye and lids. Then another layer of moist cotton is placed over the cone with the overlapping joint in a position not corresponding with that of the first layer of the cone. Still a third thin layer is put over the cone. Strips of adhesive plaster are built up from the base to the apex of the cone, to hold it in place and to strengthen it. Even if a child should lie on such a dressing, it is secure enough protection so that nothing but petrolatum could touch the eye. This should be left on for about a week. After it is removed, petrolatum should be put in the palpebral fissure before the patient goes to sleep, as long as lagophthalmos persists."

A shield resting on the margin of the orbit may be used for the same purpose. Frost devised a suture which is double armed. He passes the needles through a small rubber plate, fashioned from narrow rubber tubing, then up to the skin of the upper lid just below the brow hairs, and ties the suture over a rubber plate. This draws the lower lid up to cover the globe but not sufficiently well to permit a tight or semi-pressure dressing. It would be desirable to use a firm dressing if the globe were properly protected to prevent postoperative reaction but this is not a safe procedure.

Postoperative course. The dressing is removed after 2 or 3 days. In the case of children, there may be considerable crying and squeezing of the lids. This will put the strength and union of the tongue of muscle transplanted to the lid to a severe test. If it holds, all well and good. If it does not or if it appears that the tongue of muscle has pulled away from the lid, it is best to face the situation immediately and to locate the muscle and resuture it. The incisions separate easily by blunt dissection and in the 3 cases in which the author has found it necessary to do this, good results were obtained from resuturing.

The efforts to prevent the angulation of the upper lid by the central tongue include the use of 2 lateral tongues, the broad union of the Parinaud-Young operation (28) through the use of which a number of men have obtained successful results, the union of the levator and superior rectus as by Wiener, the Wheeler (25) union of orbicularis strips and levator, the use of fascia lata sling as by Dickey, and the tarsal sling of Trainor. The author would not favor the burial of conjunctival epithelium as in the last procedure nor would he introduce fascia lata. The use of two lateral tongues of superior rectus muscle would hinder the elevation of the globe too much. Hence there are only the procedures of Wheeler and Wiener to choose from, as some intermediary tissue placed between the lid and globe is necessary to prevent the undesirable effects of the Parinaud-Young symblepharon. The author has not decided

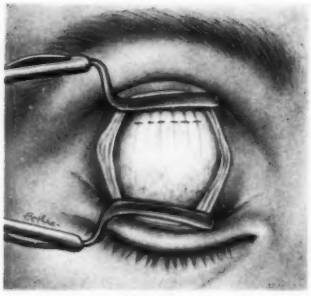


Fig. 22

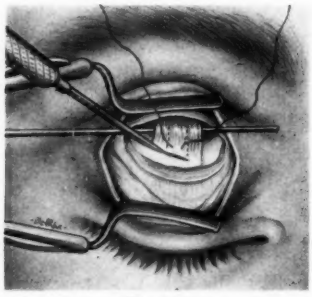


Fig. 23

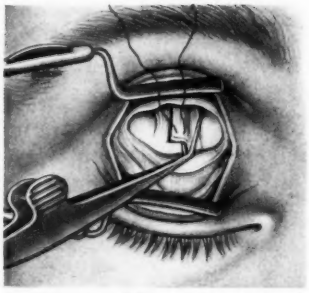


Fig. 24

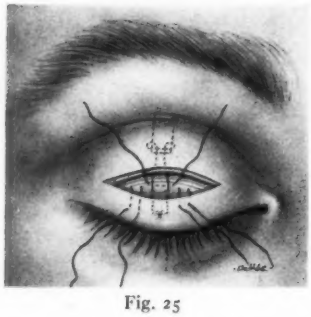


Fig. 25

Fig. 22. The skin incision has been made and speculum inserted. The tarsus and levator muscles are exposed. The broken line indicates the path of further dissection.

Fig. 23. The superior rectus has been isolated on a straight probe. The levator, smooth muscle, and Tenon's capsule are seen in successive layers. The double armed silk suture has been inserted and the fashioning of the muscle tongue has been started.

Fig. 24. The fashioning of the muscle tongue completed by incisions with DeWecker's scissors.

Fig. 25. The arrangement of sutures. The muscle tongue is transplanted to the anterior face of the tarsus; its position is secured by the double armed suture and by the transverse accessory suture. The two vertical double armed sutures prevent the folding of the loosened skin over the lashes and help in the formation of the crease in the lid.

whether he favors the Wiener or Wheeler method and is subjecting them to further trial.

7. *The technique of the Wiener method.* This method is as follows: The tarsus is exposed by an incision through skin and orbicularis. The levator is isolated between two hooks. Two sutures are placed in the levator near the tarsus. The levator is then cut free. A pocket is made through the levator above the upper border of the tarsus and through the conjunctiva into the upper cul-de-sac. A speculum is introduced into the palpebral fissure and the conjunctiva is dissected to expose the superior rectus. The two sutures are then brought down through the dissection and one is attached to each side of the superior rectus tendon 5 millimeters back of the insertion.

The author has used the principle of this operation but modifies it by avoiding the conjunctival incision, dissection, and sutures by the simpler method of using the skin incision and by performing the entire operation through the skin.

8. *Wheeler's method is as follows (25):* Avertin with the injection of procaine hydrochloride works well. The subcutaneous infiltration near the margin of the lid helps in the dissection because it magnifies the rather thin layer of the orbicularis muscle overlying the tarsus.

The dissection and exposure of the superior rectus through the skin is exactly the same as the author (13) described in 1928. Wheeler continues by dissecting strips of orbicularis muscle from the surface of the tarsus. They are set free at the ends toward the canthi but are left attached at the ends toward the center of the lid. The attached ends are about 8 millimeters apart, and the orbicularis muscle between is undisturbed. Each strip is about 10 millimeters long and 4 millimeters wide. The strips of orbicularis muscle are attached to the upper surface of the superior rectus muscle with No. 000 chromic catgut. It is well for each strip to be attached by means of two sutures, as the strips have to carry a heavy load during the healing process when the upper lid is swollen.

An ordinary probe passed between the superior rectus muscle and the sclera and allowed to project out of the dissected area on each side is useful in steadying the globe in depression while the strips of orbicularis muscle are being attached. After the orbicularis muscle is secured in contact with the superior rectus muscle the only suturing required is that of the skin. This can be closed by several fine silk sutures or by a single subcutaneous suture.

Fig. 26, left. Congenital ptosis. Resection of levator and smooth muscle of lid indicated.

Fig. 27. Notching of lid after correction by transplantation of superior rectus. Tarsal resection indicated to correct slight angular deformity.

Fig. 28, left. Congenital ptosis. Palpebral fissure actually narrower on elevation than on depression of the eyes. Direct indication for transplantation of the superior rectus.

Fig. 29. Result after transplantation of the superior rectus.

THE SURGICAL CORRECTION OF PARALYSIS OF ELEVATION

The problem of the correction of the condition of paralysis of elevation is a most difficult one, inasmuch as the eye is in a position of hypotropia, and if the lid is lifted, the globe will be disclosed to view in this position. The use of the union of the frontalis to the lid has no value for this reason. The globe must first be lifted and with it the lid, or the latter must succeed it in a two stage operation. The logical plan is to be content with the shortening and tensing of the muscle fibers, which may be atrophied, and the fascias of the superior rectus and inferior oblique, and then producing a union between the lid and the globe by a linking to the superior rectus tendon.

Wheeler (25) used this plan on a number of occasions and the author has used it 4 times with as much satisfaction as could be expected. If the fellow eye and upper eyelid are normal, it may be well to be satisfied with the unilateral ptosis because one cannot hope for co-ordination of the eyes. Only for cosmetic effect should the lid be lifted. However, if the patient is dependent on the eye with the ptosis and if the other eye is useless for the same or other reasons, this plan may succeed.

Technique. The superior rectus is shortened and advanced as follows: A transverse conjunctival incision is made directly back of the insertion; the muscle is isolated on a hook and then on a multiple-toothed muscle forceps; and the tendon is severed with strabismus scissors from its attachment to the globe. Two double armed No. 0000 10 day chromic catgut sutures are placed 2 millimeters anterior to the insertion and then passed back through the muscle fibers about 8 millimeters behind the cut edge. These sutures are tied and the muscle is resected anterior to the sutures. The conjunctiva is closed with interrupted gut sutures. The inferior oblique is then shortened and advanced according to Wheeler's (24) technique:

> "A skin incision about two centimeters long is made along the orbital margin with the anterior attachment of the inferior oblique at about its center. The dissection is carried through the tarso-orbital fascia into the orbit and the inferior oblique is exposed. The dissection is carried also downward for exposure of the periosteum a centimeter or more below the orbital margin. Two fine chromic-gut sutures are passed through the tendon near its anterior attachment, while the muscle is held on a squint hook. The tendon is cut free at its attachment and carried over the orbital margin. It is advanced as much as need be and secured to the periosteum on the facial surface of the superior maxillary bone by means of the gut sutures (000). The skin wound is then closed with fine silk sutures."

The union of the superior rectus to the lid may be effected at the same time as the advancement. The portion of the muscle which is anterior to the suture line on the globe is placed through an incision in the conjunctiva, tunneling anterior to the tarsus and attaching it to the lid as Motais did, or suturing it to the tarsus through a skin incision as Shoemaker did with the central strip of muscle. This procedure seems logical to the author and would be an excellent use for the muscle which otherwise must be cut off and discarded. The lower lid will then be brought up with a suture to protect the globe. The usual way

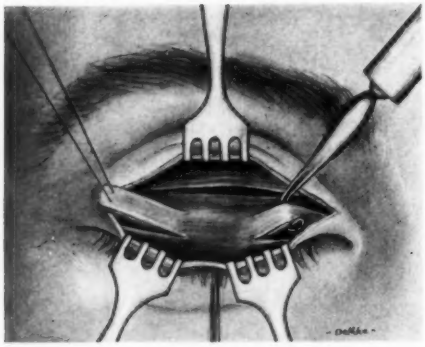


Fig. 30. Wheeler's method of fashioning tongues of muscle from the orbicularis. (*Courtesy of Archives of Ophthalmology.*)

has been to allow the eye to heal after the superior rectus and inferior oblique operation and then secondarily produce the symblepharon in the manner of Parinaud or Young.

If the tensing procedures of resection and advancement of the superior rectus and inferior oblique muscle tissues are successful in correcting the hypotropia, it may be unwise to try to support the weight of the lid also by the tension of the inert muscle tissues. The surgeon then may resort to the vicarious action of the frontalis muscle. This would be the only direct indication for employing this principle. The objections to it have been stated, first, that the lid is lifted straight up and, second, that the facial disfigurement of the arching of the brows is continued. The further objections to some of the applications of the principles, namely, the burial of foreign material or of epidermis with possible cyst formation, will be overcome if the Reese operation is employed. The technique of this is as follows:

A curvilinear incision is made along the length of the eyelid, 6 millimeters above the center and 4 millimeters above the ends of the margin. Dissection is made beneath the skin 4 millimeters above and 2 millimeters below the incision. The orbicularis is dissected off the tarsus so that two lateral tongues are fashioned; the ends are free and the bases are left attached to an area 10 millimeters wide in the center. A double edged knife is used to tunnel the brow from above in front of the tarso-orbital fascia on the 2 sides of the midline and to carry back the sutures which draw up the ends of the orbicularis flaps. A third supporting suture is used centrally. All are tied over small pieces of rolled gauze. The sutures are allowed to remain for 7 days. This operation accomplishes a union between the lid and orbicularis without the use of foreign material or burial of epithelium. In these respects it is superior to the other procedures in which the frontalis is utilized. There must, however, be some lagophthalmos; the raising of the brows must be continued for elevation of the lids and the lid is lifted straight up and not carried back over the globe.

SUMMARY AND CONCLUSIONS

The condition of blepharoptosis or drooping of the upper eyelid may be corrected surgically. The author favors, first, the improvement of the function of the levator and smooth muscle of the lid in cases in which this is partially preserved. The tarsus and muscles may be resected or the muscles may be advanced for the purpose. The direct indication is present when the ptosis is partial, when there is a partial crease in the skin, and when the palpebral fissure is wider on elevation than on depression of the eyes. Second, the procedure of transplantation of a portion of the function of the superior rectus is employed. The direct indication for this exists when there is practically no function of the levator and smooth muscle of the lid, when there is no crease in the skin, and when the palpebral fissure is actually narrower on upward than on downward gaze. This phenomenon is produced by the movement of the lower lid associated with the elevation and depression of the globe when the upper lid is practically inert. The principle may be employed even when the superior rectus is paralyzed provided the inferior oblique is active and there is no hypotropia. Third, the condition of paralysis of elevation, which exists when the levator and smooth muscle of the lid in addition to the superior rectus and the inferior oblique are all paralyzed and the globe is in a position of hypotropia, calls for the application of resection and advancement of the superior rectus and inferior oblique coupled with the formation of symblepharon between the superior rectus and the lid, or with the final elevation of the lid by the vicarious use of the frontalis muscle after the globe has been lifted from its position of hypotropia.

The techniques favored by the author for the accomplishment of these principles have been described. The results obtained by operations along these lines are as satisfactory as may be expected. The desired effects are the elevation of the lid without lagophthalmos, the removal of the peculiar facies of ptosis, the creation of a crease in the skin of the lid, and the rolling of the lid in elevation over the convexity of the globe rather than in a vertical plane.

The fact that such a multiplicity of operations have been devised and that such a large number of names have been attached to the various procedures indicates that practically each surgeon who operates for ptosis has developed a new method of his own design or variation, and that even in the hands of the most skillful surgeon, the results are not always entirely satisfactory. Every effort has been made in this paper to simplify the exposition of the principles of blepharoptosis surgery and to advocate only those which give results and which are as satisfactory as may be expected under the conditions present.

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OPERATIVE RESULTS IN DETACHMENT OF THE RETINA AT WASHINGTON UNIVERSITY SCHOOL OF MEDICINE 1934-1938

LAWRENCE T. POST, M.D., F.A.C.S., and T. E. SANDERS, M.D.,
St. Louis, Missouri

DURING the 5 year period from January 1, 1934, to January 1, 1939, a total of 113 patients with the diagnosis of detachment of the retina were admitted to the service of the Department of Ophthalmology of the Washington University Medical School. One hundred and nine of them were admitted to Barnes Hospital and the 4 remaining to Saint Louis Children's Hospital. A total of 96 eyes, on which an operation for detachment of the retina was done, is analyzed in this series, as no operation was done on 19 of these patients and 2 had bilateral operations. Previous to this period the operative technique was not standardized well enough for fair comparison, and sufficient time is allowed for a reasonable follow-up of the most recent cases.

This series consists of 73 private cases from all walks of life, with the 21 remaining from the out patient clinic. As shown in Table I, the ages vary from 8 to 74 years. The majority of patients were middle aged. Although 77 per cent of the patients were operated upon by 4 surgeons, a total of 13 different operators is represented. Eight operations were performed by the house staff. As this series represents the operative results of a large number of surgeons of varying degrees of skill and experience, in a group of patients of all ages and types, with many variations of detachments, it is an extremely fair test of the effectiveness of surgical treatment of detached retina.

Although there is some difference of opinion as to what constitutes a successful operation for retinal detachment, we believe that only those cases showing a complete anatomical re-attachment should be considered surgical successes. Even in the objectively cured case good central vision is not obtained often because of macular degeneration, but these cases must be considered surgically successful as the object of the operation in re-attaching the retina is obtained. On the other hand, all those cases without complete anatomical re-attachment must be classed as surgical failures. In the great majority of cases, there is no middle ground; the case is either a success or a failure, depending on the presence or absence of complete re-attachment. Partial surgical successes such as incomplete re-attachment, decrease in elevation of the detachment, and improved vision or field without re-attachment are better classed as failures, as the object of the operation has not been obtained, and in time most of these cases will go on to complete detachment. Although the percentage of failures will increase by adhering to these standards, the success in various series may be more easily compared, because they eliminate the term, partial success, which varies with every author.

Because of the well known tendency to redetachment, a case should be followed for a year, as have most of the cases in our series, before it can be considered a definite surgical cure. Practically none of the cases that are not flat within a few days after the operation will go on to re-attachment; but in our series there is a single patient who, after 3 apparently unsuccessful operations, returned in 8 months with a complete re-attachment and approximately full field.

In accordance with these standards of complete re-attachment with adequate follow-up, a total of 40 cases or 42 per cent of this series are judged to be surgical successes. If we eliminate the obviously unfavorable cases in which operation was done as a last resort with little hope of success, we find that we have to consider a total of 61 cases of simple, uncomplicated, unilateral detachment. In this group 33 cases or 54 per cent were successful.

In the 35 remaining cases which were considered to be unfavorable, only 7 or 20 per cent were successful. As is usually the case, no re-attachment occurred in the 9 aphacic cases, 5 of which followed intracapsular extraction, 2 followed extracapsular extraction, and 2 were in congenital cases which had had discissions. Although this group is small, it seems to give some weight to the statement sometimes heard that detachment is more common following intracapsular extrac-

From the Department of Ophthalmology and the Oscar Johnson Institute of the Washington University Medical School.

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TABLE I.—AGE INCIDENCE

Age—Years	No. of cases	No. of successes
Under 10	1	0
11–19	12	6
20–29	7	1
30–39	12	6
40–49	15	7
50–59	24	10
60–69	17	9
70–79	6	1

tion. No successes occurred in the 3 postinflammatory cases which had had uveitis, or in the 3 patients in whom the detachment had been present 2 or more years. It is obvious that these cases should be considered as unfavorable. The 9 bilateral cases are included in this group, as it is evident that there is either a general condition, or some bilateral local defect present which might tend to hinder re-attachment. Five of these bilateral cases or 45 per cent were successful. Even before this series was collected, it was observed that many patients with detachment were blind in the fellow eye from some apparently unrelated cause. In this series this is true in 9 cases or 10 per cent, which seems to be too large a percentage to be accounted for by mere coincidence. Just what mechanism is responsible is not known, but we believe these are justifiably placed in the unfavorable group. In 4 of these cases the fellow eye was blind from previous trauma, and in 5 from inactive inflammations. Only 2 of this group or 22 per cent were successful (Table II).

From the standpoint of the patient, the subjective estimate of visual acuity is a much better criterion of success than the objective, anatomical re-attachment. Of the 40 patients with complete re-attachment 10 or 25 per cent had an excellent result with an acuity of 20/30 or better; 16 or 40 per cent had a good result with acuity of 20/40 to 20/70; and in 14 or 35 per cent only a fair result was obtained, the vision being 20/100 to 10/200 (Table III).

Retinal tears were noted in 57 per cent of the cases with 45 per cent of success, while there was

TABLE II

	Cases	Per cent
Favorable	61	
Successes	33	54
Unfavorable	35	
Successes	7	20
	Cases	**Successes**
Aphacic	9	0
Postinflammatory	3	0
Over 2 years old	3	0
Bilateral	11	5
Complicated (fellow eye blind)	9	2
	35	7

TABLE III.—VISUAL RESULTS IN 40 SUCCESSFUL CASES

Vision		No. of cases	Per cent of total success
Fair	20/200 to 10/200	14	35
Good	20/70 to 20/40	16	40
Excellent	20/30 and better	10	25

only 37 per cent of success in the 43 per cent remaining in which no tear was noted. The incidence of myopia was less in this series than usually reported in the literature. Myopia of a significant amount of 2 diopters or more was present in only 18 per cent of this series with 35 per cent successfully re-attached. There was a history of definite trauma in 21 per cent of the cases, and, after eliminating the unfavorable in this group, 11 cases or 69 per cent were successes. The trauma is not necessarily directly to the eye; many followed blows on the side or back of the head, and 2 were associated with dental work in which hammering was done. There is often a definite interval of several weeks between the trauma and onset of symptoms; the tear probably occurs at the time of the trauma and the actual detachment takes some time to form.

It was surprising that in only 6 patients the detachment was chiefly in the nasal quadrant; the 90 remaining were equally divided between superior, inferior, and temporal quadrants. It is significant in the matter of prognosis, that in 73 cases with less than half of the retina detached, 48 per cent were successful, while in the 23 remaining with more than half detached, only 22 per cent were successes.

In 19 of the patients operation was done within 1 week of onset with 54 per cent of cures. In 38 cases the interval between onset and operation was from 1 week to 1 month with 40 per cent of successes. Thirty nine per cent of cures was obtained in the 28 patients with detached retinas 1 to 6 months before operation. Eight cases with 37 per cent successes were detached for 6 months to a year, and in 5 cases with 20 per cent of success, the retina had been detached over 1 year

TABLE IV.—NUMBER OF OPERATIONS PER PATIENT

No. of operations	No. of cases	Successes	Per cent success
1	56	31	57
2	27	6	22
3	9	2	22
4	2	1	50
5	1	0	0
6	1	0	0

before operation was done. Prompt operation is important not only from the standpoint of a better chance for re-attachment, but even more so in the matter of retaining good visual acuity. In 18 of the 26 cases having a vision of 20/70 or better, the operation was done in the first month.

In this series 40 or 42 per cent of the patients had more than 1 operation. Of the patients having a single procedure 57 per cent were successful. Twenty seven patients had 2 operations with 22 per cent success. Three operations were done on 9 patients with 22 per cent success, and 2 had 4 operations with only 1 success. One patient had 5 operations, another 6, but neither was successful. These were desperate one-eyed cases. After each failure the chance for successful future attempts seems less, probably not only from changes caused by the operative procedure, but also by elimination of the favorable cases (Table IV).

A total of 156 operations were performed in this series. The object of all of them was to cause an adhesive chorioretinitis with subsequent re-attachment of the retina. The majority of them were multiple diathermy punctures of the sclera; a Walker ophthalmic diathermy unit with several types of electrodes was used. In 94 cases, the barrage of scleral diathermy was laid down by multiple puncture with a single electrode; the Gradle, Lacarrere, or single straight platinum needle was used. Twenty-four of the earlier cases were done with Walker pins. Later this method was abandoned because of difficulty in the handling and application of the multiple pins. In combination with diathermy, galvanic current was used in 11 cases in an attempt to seal off the tear. In 23 cases, heat was applied to the sclera by means of the Shahan thermophore. A combination of scleral diathermy and the thermophore was used in 3 cases. A single Guist operation was done unsuccessfully on 1 patient after 4 scleral diathermy operations had been done previously (Table V).

The scleral diathermy procedures are so well standardized that they need no description here. The use of the Shahan thermophore in retinal detachment, which was first reported by Langdon, is not so well known, but also has been described by one of us (L.T.P.), when 6 of these cases in which the thermophore was used, were previously reported (3). First, the sclera is exposed as is done in the diathermy operations and one or more posterior sclerotomies done. Pains are taken to remove the subretinal fluid by aspiration if necessary. The thermophore is then applied to the bare sclera for 1 minute, at 158 degrees. With a 3 millimeter contact surface about 8 to 12 applications are made in the form of a barrage around and over the tear, if present. The chief difficulty is application to the posterior portion of the sclera behind the equator. The senior author has devised a curved contact point for use posteriorly. There is probably some advantage in doing the sclerotomies first as this puts the retina and choroid in closer approximation without danger to the retina, and there is no penetration of the sclera. This also aids in the posterior applications, as the globe is more compressible. The thermophore can be applied through the intact conjunctiva, but this seems definitely less effective.

It is extremely difficult to evaluate the effectiveness of the various types of operative procedures as the cases vary so much in type, extent, duration, and complications. In the first place, only favorable cases should be used for comparison; second, only the first operation on each case should be considered; and finally, the techniques should be as near standard as possible. With this in mind, we have figured the percentage of successes of the original operation in favorable cases for each of the operations used, as shown in Table VI. From this the thermophore seems to be the most effective, although the total number of cases is not large. It is possible that this method was used in the ideal cases and the diathermy operation reserved for cases in which there was any doubt as to method. Several of the thermophore cases showed large retinal and preretinal hemorrhages, although none of these caused permanent damage. Because of hemorrhage there has been some dissatisfaction with the present technique. It is probable that a lower temperature might be just as effective with less tendency toward hemorrhage.

TABLE V.—TYPE OF OPERATIONS

Operation	No.	Successes
Multiple scleral diathermy	94	24
Scleral diathermy Walker pins	24	5
Scleral diathermy with galvanic in area of tear	11	2
Thermophore to sclera	23	8
Thermophore and diathermy	3	1
Guist operation	1	0
Total	156	40

TABLE VI.—SUCCESS OF ORIGINAL OPERATION IN FAVORABLE CASES

Operation	Total cases	Successes	Per cent successful
Multiple scleral diathermy	37	13	35
Scleral diathermy using Walker pins	14	6	43
Scleral diathermy with galvanic current	8	2	25
Thermophore	9	7	78
Thermophore and scleral diathermy	1	0	0

It is planned to do the next group of thermophore cases with a temperature of 145 to 150 degrees.

In conclusion, the operative results in this series are very similar to some previously reported (1), with roughly half of the patients operated on for detachment of the retina obtaining a cure, and approximately two-thirds of these regaining good vision. Multiple scleral diathermy is the most popular operative procedure, but scleral application of the thermophore is a simple and effective method of treatment for retinal detachment. More general use of the thermophore in detachment would add much knowledge to a method which gives promise of being of real value.

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LATE RESULTS OF OPERATIONS FOR SEPARATION OF THE RETINA

Report of 304 Operations Performed at the New York Eye and Ear Infirmary from 1929-1938

CONRAD BERENS, M.D., F A.C.S., DONALD S. HALL, M.D., BYRON SMITH., M.D., and PAUL T. McALPINE, M.D., New York, New York

A COMPARISON of surgical results obtained in cases of separation of the retina can be only suggestive, for the cause of the detachment, the length of time from the development of the detachment to operation, and the condition of the retina and of the eyes vary markedly among individuals. However, the attempt by the American College of Surgeons to evaluate surgical results 9 months after operation should help to crystallize our ideas concerning the value of the various techniques. Moreover, these data should provide ophthalmologists with a clearer conception of what may be expected in regard to percentage of cures obtained at a later postoperative date than can be learned from available figures. In comparing the results obtained in this series of cases with those reported by other surgeons, the fact should be kept constantly in mind that these are unselected cases which had been observed for 9 months because in many of the early reports no postoperative time limit was set for publication of results.

A total of 304 operations have been performed upon 230 eyes of 224 patients at the New York Eye and Ear Infirmary. In analyzing the records of these patients, we have encountered the same difficulty that has been observed in previous studies (6), namely, that complete medical histories, routine, general, and eye examinations are rarely recorded in the average eye clinic.

Of the 224 cases, there were 103 detachments in the left eye, 107 detachments in the right eye, and 14 in both eyes. Of the 14 patients with separation in both eyes, 6 were operated upon in both eyes.

The following surgeons have granted permission to include their cases: Francis W. Shine, Bernard Samuels, Clyde E. McDannald, Ben Witt Key, Loren Guy, Brittain F. Payne, Truman L. Boyes, Wendell Hughes, Samuel P. Oast, Willis S. Knighton, Webb W. Weeks, and William B. Doherty.

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The results were classified under the amount of re-attachment of the retina, visual acuity, and visual field. The cases in which there was no complete final postoperative report after 9 months were included if the pre-operative data were complete. In most of these cases there were pertinent postoperative findings, for example, in regard to visual fields.

Influence of age and sex. Of the 224 patients, 142 or 63 per cent were males ranging in age from 5 to 80; 82 or 37 per cent were females with an age range of 10 to 74 years (Table I). In this series of cases males were more often affected.

In the 150 cases reported by Dunnington and Macnie, 64 per cent were males and 36 per cent were females. In Shapland's series (21) of 425 cases, 61.2 per cent were males and 38.8 per cent females.

It will be noted that the number of males is higher than the number of females in the patients studied by Dunnington and Macnie, Shapland, and by us. The fact that the eyes of men are more frequently exposed to injury than the eyes of women may account in part for the higher incidence of detachment of the retina among males.

A maximum number of separations occurred within age ranges of 45 to 49 years and 55 to 59 years in the males and of 50 to 59 in the females. The average age of the male group was 36 and that of the female group 38. The average age of both groups was 36.5 years.

Shapland (20) reported that the average age of 140 patients was 42.9 years. In Dunnington and Macnie's series the average age was 39.8 years. Between 20 and 60 years of age there was no material difference in the number of cases they encountered. Spratt has stated that detachment generally occurs in persons over 40 years of age.

The average age in our series is slightly lower than that in the cases reported by Shapland, Dunnington and Macnie, and Spratt. However, the average ages of the 4 groups occur between 36 and 43 years.

TABLE I.—DISTRIBUTION OF AGE AT FIRST EXAMINATION OF 224 PATIENTS WITH DETACHMENT OF THE RETINA

Age—Years	No. of males	No. of females
75–80	1	—
70–74	—	1
65–69	4	3
60–64	15	9
55–59	20	7
50–54	11	17
45–49	19	6
40–44	11	10
35–39	14	9
30–34	6	6
25–29	10	6
20–24	14	3
15–19	8	2
10–14	4	2
5–9	1	—
Unknown	4	1
Totals	142	82

The average age according to the result of operation is 40 years in the complete re-attachment group, 38 years in the partial re-attachment group, 33 in the complete detachment group, and 46 years in those cases obtaining no improvement (Table II). In Shapland's (19) report of 100 cases of separated retina, the average age of the cured cases was 34.4 years which was 7 years younger than the average age of the whole group. In our series the average age of the complete re-attachment group was 40 years which was 4 years older than the age of the entire group. Because the age distribution, when results of operation are considered, is so variable no definite correlation can be shown. These findings suggest that in this series of cases age has no bearing on the result of operation. However, advancing age may be a factor in the development of separations. Degenerative retinal changes on a circulatory and toxic basis are considered as important probable causes.

Race. Only 2 colored persons were included in this group. This is possibly explained by the fact that the number of colored patients admitted to the New York Eye and Ear Infirmary is small.

Personal history. There was an actual relationship between the patient's occupation and the detachment in 19 males and a probable relationship in 1 other. In these patients the detachment occurred following an injury while carrying on their trades. In 3 female patients there was an actual relationship between the detachment and occupation. These women were housewives and retinal separation followed trauma associated with their home duties.

Family history. Detachment of the retina was recorded in the family history in only 1 case. Although tuberculosis and allergy were reported by several patients, there was nothing of particular significance in the family history which could be correlated with retinal separation.

TABLE II.—AVERAGE AGE ACCORDING TO RESULT OF OPERATION

Result	No. of cases	Age—years
Complete re-attachment	52	40
Partial re-attachment	28	38
No improvement	40	46
Complete detachment	65	33

TABLE III.—VISUAL RESULTS

Vision	Complete re-attachment No.	Complete re-attachment Per cent	Partial re-attachment No.	Partial re-attachment Per cent
Improved	37	71	5	18
Unimproved	7	14	16	57
Not reported	8	15	7	25
Totals	52		28	

Previous medical history. Previous medical history was not recorded in 107 cases and was negative in 17. In the 100 remaining cases there was practically no diagnostic grouping of previous disease; only 1 or 2 cases were classified under the various diseases.

History of present illness. Loss of vision was the complaint most frequently recorded. There was a history of trauma in 66 cases or 29 per cent. Of this number complete re-attachment was observed after operation in 17 cases; partial re-attachment in 12; the results were not recorded in 4 cases and in 12 there was no improvement. Complete detachments following operation occurred in 21 cases. Therefore, of 62 patients in whom the results could be ascertained, 53 per cent were unrelieved, while 47 per cent were improved.

Trauma was a definite factor in producing the detachment in 30 per cent of Dunnington and Macnie's cases, and was at least a probable factor in an additional 4.3 per cent. Of the cases with a traumatic history they report that 45.1 per cent were either cured or improved. These figures are slightly lower than those reported in our series.

It must be remembered that the injury causing the detachment may occur long before separation of the retina is observed. According to Allen it is the general opinion of many ophthalmologists that there are few patients who cannot, if pressed, recall some injury. Walker believes that "a sudden jerk of the eyes, as in fright, would easily whip a retina loose if certain favorable factors were present."

Physical examination. Although the physical examination was not recorded routinely in clinical cases, 18 records indicated the presence of infection in the nasal accessory sinuses. This incidence

TABLE IV.—VISUAL RESULTS IN 49 EYES WITH RETINAL SEPARATION IN THE IMPROVED GROUP

Vision	No. of cases Postoperative		Pre-operative
20/15		1	
20/20+4		1	
20/20		4	8 (5%)
20/20–1		2	
20/30–1	26	1	
20/30	(17%)		1
20/40		3	1
20/40–1		2	
20/50+1		1	
20/50		2	
20/50–1		1	
20/70+1		1	
20/70		7	2
20/100		3	1
20/100–1		1	1
20/200		7	5
18/200		1	
10/200		3	3
8/200		2	
5/200			1
6/200		1	1
3/500		1	
2/200			2
Fingers at 1 foot		2	3
Fingers at 2 feet			4
Fingers at 3 feet			1
Fingers in light field			1
Fingers			2
Hand movements		1	13
Hand movements at 6 inches		1	
Light perception			7
Totals		49	49

seems low because in private patients, who are usually studied more carefully for chronic hyperplastic ethmoiditis, a surprisingly large number seemed to be affected with chronic sinusitis; moreover, in a majority of cases the involvement seemed to be more extensive on the side of the detachment. Later exacerbations of endophthalmitis and even the development of areas of chorioretinitis in the eye, free from retinal separation, apparently confirm the belief that low grade chronic sinusitis is an important etiological factor in a rather high proportion of these cases. Tonsillectomy had been performed before operation in 6 patients and the tonsils were considered diseased in 7 others. One patient had a chronic infection of the middle ear. Twelve records indicated the presence of serious dental infection.

The Wassermann reaction was positive in only 5 cases and had previously been positive in 2 cases. This incidence of 6.3 per cent is a little high when compared with 5 per cent in the general population (2), but hardly seems to be an important factor in the etiology of detachment of the retina in our cases.

Urinalysis revealed slight variations from normal in 30 patients. Other physical findings, for example, blood chemistry, blood count, Schilling index, and blood pressure were abnormal in a few instances but in the majority of cases these findings were not recorded.

Vision. Of the cases in which complete re-attachment occurred, vision was improved in 37, unimproved in 7, and not reported in 8 (Table III). In the group resulting in partial re-attachment, 5 obtained improved vision, while in 16 vision was unimproved, and in 7 visual results were not recorded. These findings indicate that the possibility of improving vision is not great unless re-attachment is complete.

In the entire group of 230 eyes, vision was improved in only 49 eyes (Table IV), and unimproved in 107. In 74 eyes there was no record of pre-operative vision. Table IV reveals that normal visual acuity following operation for detachment of the retina occurred in only 8 or 5 per cent of the 156 eyes, and that only 26 eyes or 17 per cent had 20/70 vision or better. Since 8 of the cases had approximately 20/70 vision, it is questionable whether the maculas in these eyes were entirely healthy.

Because these figures are discouraging from the standpoint of the functional result, they should prove an increased stimulus for the study and removal of possible underlying causes. We agree with Weekers and Hubin (30) that the amount of visual recovery depends not upon the extent of re-attachment but upon the degenerative changes which have occurred in the retina.

Changes in field of vision. The visual fields in 36 eyes or 16 per cent were improved. Of our entire series, 24 or 10 per cent had improved vision combined with improved visual fields. Because the methods of examining visual fields varied, the data could not be compared accurately. However, 9 patients or 4 per cent were reported to have normal visual fields after operation.

In our series the pre-operative defect in the field of vision corresponded approximately with the area of detachment. When re-attachment occurred after operation, the field for form was usually greatly improved. However, residual defects were generally observed when separation had been present for several months.

Tension. Lowered ocular tension is generally believed to accompany idiopathic retinal detachment. Moreover, some ophthalmologists have stated that primary hypotony is a cause of detachment of the retina. However, Amsler and Schiff-Wertheimer believe that most cases of detachment of the retina are not associated with a

TABLE V.—EFFECT OF PRE-OPERATIVE APHACIA UPON RESULT

Result	Cases No.	Per cent	
Complete re-attachment	2	18	45 per cent
Partial re-attachment	3	27	
Complete detachment	6	55	
No report	3		
Total	14		

change in ocular tension. This is the finding in our cases, for pre-operative and postoperative tension were normal except in a small number of cases. If a recent retinal detachment is associated with hypertension, a tumor in the choroid should be suspected. Postoperative tension was low in 29 cases, while in 7 tension was high.

Although postoperative hypotension may be caused by the surgical procedures, in many cases the function of the ciliary epithelium might possibly have been influenced by some toxic factor, as evidenced by endophthalmitis often affecting both eyes. Our results suggest that the operation usually has no marked permanent effect upon tension of the eyeball and that extremely low tension suggests a poor prognosis.

Motor anomalies. There seems to be little relation between the surgical results and whether or not the muscles were detached. In some cases there was temporary weakness of the muscles regardless of whether they were detached or stretched. Annoying diplopia was not a factor in our cases.

Refraction. Myopia was present in 68 per cent of the cases. Spratt has stated that 80 per cent of all cases of detachment occur in myopic eyes. In Shapland's (20) series of 140 cases of retinal detachment, 81 had myopia or 62.3 per cent. Dunnington and Macnie report an incidence of 61.9 per cent of myopia. The 68 per cent of myopia in our series of retinal detachment seemed to be slightly higher than the 39 per cent occurring in patients admitted to the refraction clinic of the New York Eye and Ear Infirmary during 1938. Therefore, myopia seems to have been a predisposing factor in producing retinal separation in these cases. In patients who obtained complete re-attachment after operation, myopia was present in 17 or 33 per cent and hyperopia in 6 or 12 per cent. Of the entire group, hyperopia was present in 23 per cent and emmetropia in 9 per cent.

Cornea. Pre-operative corneal pathology was present in 24 cases. Involvement of the cornea before operation apparently had no relation to the detachment except possibly in 2 cases in which keratic precipitates were observed.

Uveal tract. In 37 patients there was a pre-operative abnormality of the iris or pupil. Of this group, iridocyclitis had been present in 2, iritis in 3, and uveitis in 6 patients.

TABLE VI.—RESULTS FOLLOWING OPERATIONS FOR SEPARATION OF THE RETINA IN 185 EYES IN TERMS OF THE AMOUNT OF RE-ATTACHMENT OF RETINA

Results	No.		Per cent	
Complete re-attachment	52	80	28	(43%)
Partial re-attachment	28		15	
No improvement	40		22	
Complete detachment	65		35	
Total	185		100	

Pre-operative choroiditis was recorded in 19 histories and chorioretinitis in 10. In another case iris bombé occurred. In some cases the signs of inflammation and trauma observed were possibly related to the detachment. In many cases of retinal separation the presence of choroiditis and chorioretinitis combined with endophthalmitis and other choroidal lesions are additional evidence indicating the presence of low grade inflammatory lesions.

Lens. In 52 patients there were some opacities in the lenses before operation.

The impression seems to be general that re-attachment of the retina rarely occurs in aphacia. Although complete re-attachment occurred in only 2 of the 14 cases of aphacia or 18 per cent (Table V), 5 cases or 45 per cent had some postoperative re-attachment of the retina. This percentage compares rather favorably with the percentage of complete and partial re-attachments obtained in the entire group.

Shapland (22) has reported that of 28 cases of retinal detachment following extracapsular cataract extraction, 3 or 18.75 per cent were cured. In another group of 15 patients with aphacia following retinal detachment observed by Shapland, only 1 had a reposition which lasted for only 9 days.

Because our group of cases is small, a comparison of our results with those of Shapland is difficult but a higher incidence of re-attachments seems to have been obtained in the patients operated upon at the New York Eye and Ear Infirmary.

Vitreous. The presence of vitreous opacities was recorded in 113 cases before operation. In 107 there was no record of changes in the vitreous. Dunnington and Macnie found pre-operative opacities in practically all their cured and improved cases.

Low grade chronic endophthalmitis was suspected as having existed in a high proportion of our patients. Moreover, clinical experience has proved that both eyes are usually affected. These points are highly suggestive that the possibility

TABLE VII.—A COMPARISON OF RESULTS REPORTED BY VARIOUS SURGEONS

Surgeon	No. of cases	No. of eyes	Posterior sclerotomy	Diathermy	Trephine	Guist-Lindner	Gonin	Sourdille	Guist	Scleral trephine (Lindner)	Electrolysis	Electrolysis and diathermy	Complete re-attachment or cured	Successful or improved	Failure
Wiener	7		7										2 29%		
Larsson	40			40										16 40%	
Baer and Shipman	22			19		6								8 36.3%	
Peter	12			12									10 83%		2 17%
Shapland	346			72		79	221						115 31%	45 12%	212 57%
Dunnington & Macnie		155		28		92	6						59 38%	15 9.8%	81 52.2%
Imre	167												92 56%		
Ramach		154		62		71			15	6			75 48.7%		
Lindner		19								19			13 68%		
Lazerev	14						11	3					6 43%	5 36%	3 21%
Knapp	12			12									8 66%	2 17%	2 17%
Terrien, Veil and Dollfus	110			8		20	82†						‡46 42%	5 5%	6 6%
Sourdille	169							169					71 42%	6 3%	
Gonin	300						300						120 40%		
Berens, Hall, Smith and McAlpine		185		175	34		15		12		6	4	52 28%	28 15%	105 57%
Gradle and Meyer	63			40*			19		4				19 30%	12 19%	32 51%

*29 Gradle.
†In this group are included 6 multiple perforating puncture combined with galvanocauterization and 25 Paufique operations.
‡1 slight recurrence.

of a low grade chronic inflammation of the tissues of the eye is a predisposing factor to retinal separation in many patients.

Hemorrhage in the vitreous was present before operation in 2 patients. There was a membrane in the vitreous in 1 eye and exudate in another.

Greeves emphasizes the fact that spontaneous vitreous hemorrhage may be caused by retinal detachment. However, none of his patients developed postoperative hemorrhage in the vitreous. When hemorrhages occur, the prognosis is apparently good in regard to surgical results.

Optic nerve. Retrobulbar neuritis occurred after operation in 4 patients. This disease also may point to the presence of chronic infection.

Transillumination. Transillumination failed to reveal a tumor in our series of cases. However, in 1 case, which was later enucleated because of glaucoma and pain, a small sarcoma was found near the posterior pole. In another case, which was not included in this series, transillumination was apparently normal but when the operation was commenced a perforating tumor was found.

Results following operation for detachment of the retina in 185 eyes. Complete re-attachment occurred in only 52 eyes or 28 per cent (Table VI). Of these 71 per cent had improved visual acuity but only a few had useful vision. Only 28 eyes or 15 per cent obtained partial re-attachment; there was some re-attachment of the retina in 43 per cent. These figures are interesting when compared with visual acuity—improvement in the latter occurred in only 49 eyes or 21 per cent. Therefore, there is opportunity for improving our results.

Gradle and Meyer conclude that if practically all eyes with retinal detachment are operated upon by modern methods, re-attachment will occur in somewhat less than 50 per cent, but if only selected eyes are operated upon, the percentage of re-attachments will be nearer 70.

Cures have been reported in ophthalmic literature in from a third to a half of patients operated upon (Table VII). Therefore, it may be seen that the results following operation for detachment of the retina are markedly different. This is natural considering the varying etiologies, condition of the retinas, and the differing lengths of time after operation when the reports were made. In comparing the results with those of other surgeons, the 9 months' postoperative period of observation in these cases should be considered.

Description of operations employed by surgeons at the New York Eye and Ear Infirmary. In all operations performed by surgeons at the New York Eye and Ear Infirmary, the sclera over the involved area of detachment is exposed; a canthotomy or temporary tenotomy is performed, if necessary. In the last few years, however, fewer muscles have been severed even temporarily.

The following operations which were performed on patients operated upon for detachment of the retina at the New York Eye and Ear Infirmary, have been employed for varying periods of time from 1929 to 1938. However, at the present time, 5 of the 6 senior surgeons use diathermy alone or combined with trephine, and 1 senior surgeon uses electrolysis combined with diathermy.

Gonin operation (cautery puncture). An incision is made close to the area of the tear and an actual cautery tip inserted through the sclera into the vitreous and allowed to remain from 4 to 5 seconds. In some cases the sclera is trephined before the cautery is applied. As many as 3 punctures are made, depending upon the size or number of holes in the retina.

Guist-Lindner operation. Chemical cauterization of the choroid is made through a trephine opening in the sclera. Two or 3 trephine openings, 1.5 millimeters, are made in the sclera over the site of the tear and sometimes as many as 15 or more are made over the area of detachment. Potassium hydroxide is applied to the choroid which then is neutralized with a 0.5 per cent solution of acetic acid. The wound is irrigated with physiological saline solution. Subretinal fluid is allowed to escape by perforating one or more of the trephine openings with a blunt probe.

Safar operation. Using a diathermy current of about 30 milliamperes, small needles about 1.5 millimeters in length are placed over the retinal tear, then over the entire area of the detachment. After all the needles are placed, they are removed, allowing free escape of subretinal fluid.

Larsson operation. A ball electrode of about 1.5 to 2.5 millimeters in diameter is applied to the sclera for about 5 seconds and electro-endothermy is used. These applications are made at several places a few millimeters apart; no precise localization of the hole is attempted. The subretinal fluid is evacuated by one of the usual methods.

Diathermy with the Lacarrere needle. Numerous diathermy punctures are made with the Lacarrere needle throughout the entire area of detachment. A special attempt is made to exclude or obliterate tears.

Diathermy with Walker pins. Small needles are inserted over the area of detachment, encircling the tear especially. The diathermy current is adjusted so that little pressure is needed when placing the needles. They are allowed to remain *in situ* until all punctures are made.

Electrolysis combined with diathermy. Electrolytic punctures are made over the entire area of detachment and sometimes in the area where the retina is not detached, especially if this area is in the superior quadrants. The first puncture is made in the places where the tear or tears have been localized. The ophthalmoscope is used to control the further application of the needles in the region of the tear by observing the location of the bubbles in relation to the tear. Special care is taken to surround the retinal tears if they are present. Moreover, an attempt is made to wall off a disinsertion at the ora serrata. The punctures are made with straight and angulated Walker iridoplatinum needles especially sharpened, and a 1.5 milliampere current is used. Diathermy and the Walker bident electrode are then employed to cover the same area in an attempt to shrink the sclera and develop more extensive adhesions between the choroid and retina. Several completely perforating punctures are made around the tear and where drainage will be favored. If the inferior part of the retina is involved, complete perforations are placed on each side of the inferior rectus.

Some surgeons seem to be reverting to the electrolysis operation, proposed originally by Schoeler, in 1889, and also advocated by Verhoeff, in 1917, as one of the best methods of treating these detachments. At the time Verhoeff proposed the use of electrolysis he did not seem to stress the importance of finding and closing the tear.

It is now conceded by most ophthalmologists that the tear must either be closed or surrounded by a water-tight ring of scar tissue. Although

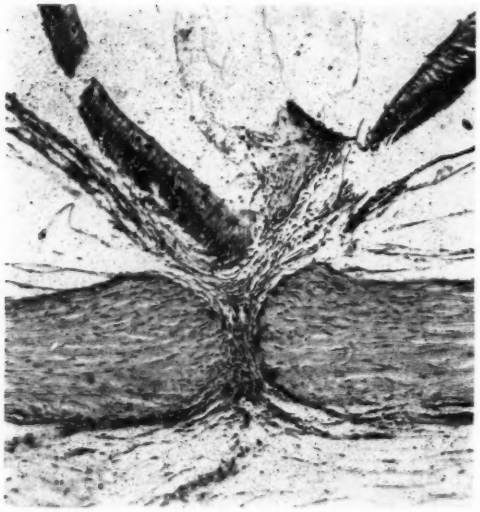

Fig. 1. Episcleral proliferation through electrolysis puncture wound in the eye of a rabbit. Note firm localized cicatrix present after 8 days.

satisfactory results seem to be increasing in number, better methods of producing adhesions between the sclera, retina, and choroid are being sought. It has been demonstrated by Weekers (29) in experiments on rabbits and in one human eye (28) that proliferation of the episcleral tissue into the wound makes the firmest adhesion between the three structures (Fig. 1). Proliferation of the episcleral tissue is evident 8 days after electrolytic puncture of the sclera in a rabbit's eye. Weekers believes that the episcleral process produces more circumscribed but stronger attachments than the choroidal process. The adhesive choroiditis produced by surface coagulation affects a larger area of the retina, but because the adhesions are not so firm recurrences are more likely to develop.

Weekers further demonstrated that it makes little difference apparently whether a knife, an electrolysis needle, a diathermy needle, or trephine is used as long as the sclera is perforated. This fact probably explains why good results are obtained by so many different methods. The episcleral proliferation will penetrate through a fine scleral wound made with a narrow Graefe knife. However, diathermy or electrolysis tend to control bleeding and facilitate the proliferation of the episcleral connective tissue.

Relation of duration of detachment at the time of first operation to result. These data concerning the relation of duration of detachment to the time of first operation seem to indicate that better results may be expected if the detachment has not persisted more than 1 month. However, the figures on complete and partial re-attachment are not sufficiently different to be conclusive evidence (Table VIII).

TABLE VIII.—RELATION OF DURATION OF DETACHMENT AT TIME OF FIRST OPERATION TO RESULT

Result	Duration 1 month or less	1 to 3 months	3 months or longer	no record	total
Complete re-attachment	22	10	15	5	52
Partial re-attachment	11	3	6	8	28
Complete detachment	19	11	22	13	65
No improvement	16	9	11	4	40
Total	68	33	54	30	

Weekers and Hubin (30) state that if re-attachment does not occur, the recovery of function depends upon the length of time the detachment has existed and upon the underlying cause of the detachment.

The results obtained by Dunnington and Macnie were just as good in the cases of over 3 months' duration as they were in those of less than 1 month's duration.

According to Ellett and Rychener cases treated within the first few weeks, rather than months, respond best. In their cases the time of operation varied from 6 days to 6 months following the detachment. Their final results were in agreement with the general belief that early interference usually produces the best results.

However, opinions vary concerning the importance of the duration of the detachment. Gradle and Meyer believe that in the average case the long duration of the detachment, within reason, is not a contra-indication to operation. In our opinion, since the individual case varies from others in many ways, no sweeping conclusion should be drawn.

Extent of pre-operative detachment in relation to the result. The figures for the extent of the pre-operative detachment in relation to the result

TABLE IX.—EXTENT OF PRE-OPERATIVE DETACHMENT IN RELATION TO THE RESULT

Extent	Complete re-attachment	Partial re-attachment	Complete detachment	No improvement
Total	3		23	1
Three-quarters	2	3	6	3
One-half	13	7	23	31
One-quarter	24	13	10	4
No report	10	5	3	1
Total cases	52	28	65	40

seem to indicate that the greater the detachment the less likelihood of re-attachment (Table IX). The largest number of complete re-attachments occurred in those cases in which ½ and ¼ of the retina had been detached before operation. Of the cases resulting in partial re-attachment the largest number occurred in those in which ¼ of the retina had been detached before operation. Of the cases resulting in complete detachment the largest number occurred in those in which the retina had been totally or ½ detached before operation. If detachment is extensive, the operative field must necessarily be larger. According to Gradle and Meyer the extent of the detachment is an important factor in the prognosis.

Relation of original site of detachment to result. The site of the original detachment did not seem to influence the final result from the standpoint of re-attachment of the retina (Table X). Dunnington and Macnie reached this same conclusion.

Relation of tears and disinsertions to result. These figures seem to indicate that although tears were found in 67 cases or 29 per cent, their presence was not an important factor in obtaining re-attachment (Table XI).

Multiplicity of tears did not seem to be important in either the re-attachments or complete failures in this series. However, in operations on private patients one of us (C.B.) has had poorer results in the presence of multiple tears.

In the cases reported by Gradle and Meyer, holes or tears in the retina were discovered in 55.7 per cent. They believe that the hole plays a rôle but how great a rôle is still undetermined.

The necessity of locating and closing retinal holes has been questioned by many ophthalmologists. In 1925, Weekers stated that since holes are not always present, they should not be considered indispensable to the production of detachment.

Ellett and Rychener believe that locating and sealing the tear is important. A contrary opinion is held by Dunnington and Macnie for in their cases the "blind" operations were almost as successful as those in which holes were located and treatment concentrated around them.

In Shapland's report (20), a retinal hole or holes were found in 80.7 per cent. In his series of cases, disinsertions were multiple in 9.3 per cent and combined with other types of retinal holes in 11.6 per cent. Gradle and Meyer believe that disinsertions must be considered individually for the seriousness of a disinsertion is governed by the extent. They state that if the retina curls back and cannot be brought forward into place, a disinsertion is a contra-indication to operation. The

TABLE X.—RELATION OF ORIGINAL SITE OF DETACHMENT TO RESULT

Site	Complete re-attachment	Partial re-attachment	Complete detachment	No improvement
Superior nasal quadrant	12	6	16	15
Superior temporal quadrant	19	10	22	20
Inferior nasal quadrant	16	10	22	19
Inferior temporal quadrant	18	9	28	22
Complete	2	1	19	1
No record	15	5	15	6

incidence of disinsertions in our cases was low; only 5 were recorded in the entire series.

The consensus of opinion seems to be divided concerning the importance of finding and sealing tears in relation to the result. In our opinion when a tear is present special effort should be made to close it. Moreover, closure or failure to close these tears or to exclude disinsertions is an important factor in the final results obtained.

Clinical type of retinal detachment in relation to result. The records were incomplete for the classification of cases according to the clinical type of retinal detachment. Moreover, they were so contradictory that no useful conclusions could be deduced from these figures in relation to the result (Table XII).

It is reported by Dunnington and Macnie that in 150 cases most of the detachments were bullous. However, the percentage of cures and improvement was essentially the same for the different clinical types of detachments.

Relation of type of operation to result. The low number of Gonin and Guist operations reported in this series of cases indicates that the diathermy operation is the one favored (Table XIII).

The highest percentage, or 23 per cent, of complete and partial re-attachments was recorded following the diathermy operation; the next best

TABLE XI.—RELATION OF TEARS AND DISINSERTIONS TO RESULT

Tears and disinsertions	Complete re-attachment	Partial re-attachment	Complete detachment	No improvement
Tears	14	1	12	7
Angular	1		1	
Irregular or curved	1	1	2	1
Horseshoe	5	1	3	2
V-shaped	1		3	
Multiple holes	1	2	1	1
L-shaped	1			
Linear		2	3	
No tear	7	3	13	6
No report	20	18	27	21
Disinsertions	1	2	2	

TABLE XII.—NUMBER OF CASES OF EACH TYPE OF RETINAL DETACHMENT IN RELATION TO RESULT

Type	Complete re-attachment	Partial re-attachment	Complete detachment	No improvement	No record
Flat	7	2	5	1	1
Bullous	3	1	17	12	5
Horizontal		1			
Mixed			2	1	4
Serous			1		
No record	42	24	40	26	35
Total	52	28	65	40	45

results, or 6 per cent, were recorded after the trephine operation. However, the number of operations in each group is too small to draw definite conclusions (Table XIII).

Relation of result of retinal detachment operation to number of operations performed. From a study of the relation of the result to the number of operations performed, the successes were in indirect proportion to the number of operations required (Table XIV).

Our experience is in accord with Gradle and Meyer's suggestion that a second operation should not be performed too soon after the first. A delayed or slow improvement often occurs in cases in which diathermy is applied and the eye should not be subjected to insult before signs of traumatic inflammation have subsided almost completely.

Operative complications in 224 patients during operation for detachment of the retina. In view of the amount of traumatism which is unavoidable in performing some of these operations, the number of complications during operation seems to be small. Moreover, no serious complication was recorded in this series of operations (Table XV).

Postoperative eye complications. Considering the length of time that these patients must remain quiet in bed, frequently with both eyes bandaged, it is surprising that the amount of postoperative delirium is low (Table XVI). The use of sedatives may play an important rôle in the production of

TABLE XIII.—RELATION OF OPERATION TO RESULT

Operation	Complete re-attachment	Partial re-attachment	Complete detachment	No improvement	No record
Diathermy	40	30	68	37	33
Diathermy and electrolysis	1	1	2		
Electrolysis	2	2		2	
Gonin	4	2	7	2	8
Guist	2	1	7	2	3
Trephine (Thompson)	8	11	13	2	4
Not stated	1		5	3	1
Total	58	47	102	48	49

TABLE XIV.—RELATION OF RESULT OF RETINAL DETACHMENT OPERATION TO NUMBER OF OPERATIONS PERFORMED

No. of operations	Complete re-attachment	Partial re-attachment	Complete detachment	No improvement	No report
1	52	28	66	40	44
2	4	13	26	6	2
3	1	4	6	2	2
4	1	1	2	—	1
5	—	1	1	—	—
6	—	—	1	—	—
Total	58	47	102	48	49

delirium. However, in a series of 1,004 cataract operations, delirium occurred in only 2 cases (5).

The only complication which occurred sufficiently frequently to be considered serious was postoperative hemorrhage into the vitreous in 6 cases. This would seem to be a surprisingly low incidence of hemorrhage considering the diseased condition of many of the eyes, the age of the patients, and the degree and extent of insult to the vascular system of the eyes. According to Gradle and Meyer subsequent hemorrhage into the vitreous is still one of the great dangers of operation for retinal detachment. They believe that this danger is less following diathermy operations.

Complications in Shapland's cases (20) were notably small in number. They were occasional small subretinal and intrachoroidal extravasations of blood, secondary rents in 12.2 per cent of the cases, 2 cases of uveitis, 2 of possible localized choroidal infarcts, and 1 of complete vitreous hemorrhage.

Incidence of postoperative cataract compared with result of operation. From clinical observations apparently cataract is more likely to develop if the retina is not re-attached. Although this number of cases is hardly sufficient to present conclusive evidence on this point, the figures suggest that this clinical impression is strengthened by these data. In the complete re-attachment series only 1 cataract developed after operation (Table XVII).

TABLE XV.—OPERATIVE COMPLICATIONS IN 224 PATIENTS FOLLOWING OPERATION FOR DETACHMENT OF THE RETINA AT THE NEW YORK EYE AND EAR INFIRMARY

Complication	No. of cases
Low tension of the eyeball	10
Loss of vitreous	3
Vitreous hemorrhage	2
Hemorrhages in retina	1
Hysteria	1

TABLE XVI.—POSTOPERATIVE EYE COMPLICATIONS

Complication	No. of cases
Secondary glaucoma	3
Spontaneous hemorrhage in vitreous	6
Traumatic hemorrhage (after fall)	1
Corneal abrasion	1
Ulcers of cornea	1
Endophthalmitis	4
Iridocyclitis	2
Dislocated lens	2
Retinitis proliferans	1
Iris bombé	1
Degeneration of the retina	1
Hypotony	1
Pain	1
Hemorrhage at site of operation	1
Degeneration of macula	1
Delirium	1
Total	28

Dunnington and Macnie report that no successful case in their series developed clouding of the lens as a postoperative complication. Of the cases in which complete detachment resulted, cataracts developed in 12. Our clinical experience suggests that cataracts eventually develop in all cases of complete detachment and that Table XVII does not give the picture, which would be presented if all the cases of complete detachment were observed after 5 years.

Postoperative general complications. The general complications were varied and few in number (Table XVIII). Apparently they bear little relation to the operation for retinal separation unless possibly the necessary confinement in bed for such a long period of time.

TABLE XVII. — INCIDENCE OF POSTOPERATIVE CATARACT COMPARED WITH RESULT OF OPERATION

Result	Total no. of eyes	No. of eyes developing postoperative cataract
Complete re-attachment	52	1
Partial re-attachment	28	3
No improvement	40	4
Complete detachment	65	12
No report	45	1
Total	230	21

TABLE XVIII.—POSTOPERATIVE GENERAL COMPLICATIONS

Complication	No. of cases
Large abscess of buttock	1
Acute fibrinous pleuritis	1
Coronary thrombosis	1
Phlebitis of both lower extremities	1
Total	4

SUMMARY AND CONCLUSIONS

1. From 1929 through 1938 a total of 304 operations were performed upon 230 eyes of 224 patients at the New York Eye and Ear Infirmary. Clinical records are usually incomplete, particularly concerning re-examination after 9 months. Therefore, follow-up should be improved.

2. The average age of these patients was 36.5 years. Advancing age seems to play an important rôle since a maximum number of detachments in the patients operated upon at New York Eye and Ear Infirmary occurred within an age range of 45 to 59 years. No correlation seemed to exist between age of patient and surgical result.

3. There were 142 males and 82 females included in this series. These figures agree with those of other surgeons which indicate that there is a higher incidence of retinal detachment in males. Exposure to traumatism may be a factor.

4. The medical history apparently showed little correlation with the development of retinal separation except possibly in regard to trauma. There was a history of injury in 66 cases or 29 per cent.

5. The general physical examination revealed unimportant data in these patients except concerning focal infection, especially oral and nasal accessory sinus disease. Sinus infection was usually more active on the side of the retinal separation.

6. Vision was improved 9 months after operation in a low percentage of cases or in only 21 per cent.

7. The 16 per cent of cases in which the field of vision was improved after 9 months is even lower than the number in which vision was improved.

8. In only 24 cases, or 10 per cent, were vision and visual fields improved. These percentages seem quite low.

9. Pre-operative and postoperative tension were normal with the exception of a few cases. Operation for detachment of the retina usually had no marked permanent effect upon tension of the eyeball; extremely low tension apparently suggested a poor prognosis.

10. No definite correlation could be discovered between motor anomalies and the development of the retinal separation. After operation, no serious diplopia was complained of, even though muscles were detached in several cases.

11. Myopia was present in 68 per cent of the cases and hyperopia in 23 per cent. From these data and the figures of others, myopia and trauma seem to be important, predisposing, or exciting factors in development of separation of retina.

12. In only 2 cases in which keratic precipitates were present before operation was there any possible relation between corneal pathology and detachment of the retina.

13. Pre-operative choroiditis occurred in 19 cases, chorioretinitis in 10, and vitreous opacities in 113 cases. A number of cases showed evidence of previous inflammation of the iris and ciliary body. Therefore, vitreous opacities and evidence of past inflammation of the uveal tract occurred in a high percentage of eyes before operation. These findings suggest the presence of a low grade inflammatory process as a possible factor in the etiology of retinal separation.

14. In only 5 of the 14 cases in which aphacia existed before operation was there complete or partial re-attachment of the retina. This 45 per cent of improvement is high in the light of our own statistics and those of other surgeons. Therefore, these results may indicate that the pessimism concerning separation of the retina associated with aphacia may not always be warranted.

15. Transillumination apparently was normal in the majority of the cases. However, sarcoma of the choroid was discovered later in 1 patient, and in another operation for detachment of the retina was discontinued because of the discovery of a perforating sarcoma.

16. The operative procedures of 5 senior surgeons at the New York Eye and Ear Infirmary at the present time are limited to diathermy alone or combined with trephine, and 1 senior surgeon uses electrolysis combined with diathermy. The majority of the operations performed are variations of the application of diathermy.

17. Complete re-attachment occurred in 52 eyes after operation, partial re-attachment in 28 eyes, no improvement in 40 eyes, complete detachment in 65 eyes, and no complete examination after 9 months was recorded in 45 eyes. Therefore, complete and partial re-attachment were present after 9 months in 80 of the 185 eyes.

18. The largest number of cases had detachment of the retina for less than 1 month at the time of the first operation and the greatest number of complete and partial re-attachments occurred in this group of eyes. However, no valid conclusions can be drawn from the data concerning the duration of the detachment at the time of the first operation and the result; since the number of cases with complete and partial re-attachment, when the operation was performed after 3 months, was almost as great as in the patients operated upon within 1 month.

19. Of the cases with pre-operative total detachment, only 3 were completely re-attached, while 2 of the three-quarter detachments were re-attached. Of the cases in which three-quarters of the retina was separated before operation, partial re-attachment was obtained by only 3, by 7 in which one-half of the retina had been detached, and by 13 of the cases in which one-quarter of the retina had been separated. These statistics indicate that the more extensive the detachment the less likelihood of re-attachment.

20. The site of the detachment was about equally divided among the quadrants in these 230 eyes. The original site of the detachment seemed to bear little relation to the final result of operation.

21. Tears were observed in 67 eyes. The presence or absence of tears apparently bore little relation to the final result but experience in these cases suggests that when tears or disinsertions are present they must be closed or excluded.

22. In the majority of cases some form of diathermy operation was employed. Therefore, no important conclusion can be drawn concerning the comparative value of the different types of operation.

23. The largest number of operations were performed upon the unsuccessful cases. These data suggest that if the first operation is unsuccessful, good results after 9 months from multiple operations are seldom obtained.

24. Operative and postoperative ocular complications occurred in only a few cases and seemed to be unimportant as far as the final result was concerned. The only serious complication was vitreous hemorrhage in 6 eyes.

25. Postoperative cataract developed rarely when the retina was completely re-attached. This occurred in only 1 of 52 eyes in our series. Eyes with complete detachment of the retina developed cataracts after 9 months in 12 instances. These data seem to substantiate clinical experience which indicates that cataracts eventually develop in all eyes with permanent complete detachment of the retina.

26. From the viewpoint of re-application of the retina, the operative treatment of detachment of the retina seems to be improving. However, because late visual and visual field results are often disappointing, more knowledge of the cause and prevention of serious retinal pathology, especially in the macular area of the retina, is urgently needed.

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REPORT OF OPERATIONS FOR DETACHMENT OF THE RETINA AT THE MAYO CLINIC

WILLIAM L. BENEDICT, M.D., F.A.C.S., Rochester, Minnesota

IN the summer of 1930, my associates and I began a series of operations for detachment of the retina, after the method described by Gonin and modified by other surgeons in this country and abroad. Since we had not previously operated for retinal detachment, we had no clinical experience on which to base a selection of suitable patients nor had we any definite plan of postoperative care. Previous to that time we had noted rents in the retina in some instances of detachment, but we had not instituted careful search for rents, tears, or holes in the retina because they held for us only academic interest. It was only after the significance of the rents had again been emphasized by Gonin in reference to surgical treatment that we began to scrutinize them with reference to the sclera. Several methods of localizing retinal tears were published in current journals and some were utilized, while others were found to be too complicated for the added degree of accuracy attained by their use.

The actual cautery was used in 18 operations on 15 patients in the period of 2 years. At the clinic we used Post's electric cautery designed for the purpose, rather than Paquelin's cautery, because of the greater care with which the new instrument could be handled. All patients operated on had extensive detachments with rents that were localizable. Vision, with 2 exceptions, was reduced to perception of moving objects only; and since the eyes of these patients were doomed to blindness without treatment, the risk of operation could not be a marked deterrent.

The detachment was recent or within 3 months in 5 cases, the most recent one, 8 days, the most ancient one, 3 years. In 1 case, the retina had been detached only 3 weeks and the vision in the affected eye was 6/10. Six weeks following the operation, the vision was 6/10 and remained at that value with full field of vision and anatomical restoration of the retina for 2 years. The retina then became detached again with vision reduced to 6/100. The eye was operated on by fulguration, but the result was not satisfactory. Some months later the eye was removed for endophthalmitis. The retinas of 2 other patients became re-attached after performance of a Gonin type of operation; but vision, which had not been better than perception of moving objects before operation, was not improved. In other cases, the retina seemed to be satisfactorily restored to its normal position for a few weeks but the vitreous body was hazy as a result of either hemorrhage or reaction to the operation. Recurrence of the detachment was not uncommon. In 6 cases the retina remained detached after the operation. No eyes were lost as a direct result of the cauterization. Summing up the results of the Gonin type of operation, there were 18 operations on 15 patients with no permanent satisfactory results.

The failures may be attributed to several factors: (1) Most of the instances of detachment were not favorable for a satisfactory outcome. (2) There was complete inability to close the hole in the retina or failure to find all openings in cases of multiple rents or holes. (3) Hemorrhage at time of operation was often severe and clouded the vitreous. (4) Severe reaction to the operation occurred in some instances with some loss of vitreous followed by very low tension and eventually by phthisis bulbi. (5) Patients were kept in bed only 2 weeks, whereas they should have been kept quiet for a longer time.

At the clinic in the latter part of 1932, we abandoned the Gonin operation and for several months did no operations for retinal detachments. We began to use the Safar type of operation in February, 1933, and employed various modifications during the following years. The results of these operations have, on the whole, been rather encouraging. While the criterion of success has not been defined, it may be well to state that instances in which our operations have been successful have been so classified on the basis of visual acuity, visual field, and restoration of the retina to its normal position. In all 3 respects, the eye must appear to be as well or better than it was before operation. Ever since we began to employ the fulguration operation our results have been uniform. They are not better for the year 1938 than they were for the years 1933 and 1934. While there have been changes in technique that have

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materially shortened the time required for operation and lessened trauma, only the operation has been simplified.

While discussing technique, I might say that as we do the operation now, it requires only 20 to 30 minutes. Briefly stated, the following are the important time saving points: (1) General anesthesia is obtained by the intravenous administration of pentothal sodium. (2) Tendons of ocular muscles are not divided. They are retracted by hook when necessary. (3) The rent or rents previously have been localized accurately. (4) A single needle is employed; it is possible with Gradle's needle to reach the globe at any point without difficulty. (5) Subretinal fluid is drained after fulguration is complete; an electrically driven trephine is used to make an opening through the sclera 1 millimeter in diameter in the dependent portion of the area of the detachment. (6) The patients in whom the retina becomes re-attached are kept in bed with eyes bandaged for 25 to 30 days, at the end of which time pin-hole goggles are worn for another 30 days.

Two patients of this latter group had bilateral aphacia. In 1 patient the retina in each eye became detached 3 years following successful intracapsular extraction of cataract done elsewhere. The interval between operations for cataract was 1 year, and between detachment 1 year, in the order of the previous operations. Results of the fulguration operations were satisfactory, resulting in vision of 6/12 in each eye and preservation of nearly normal visual fields. In 1 other aphacic eye the visual field was restored to nearly normal and the retina was replaced, but the visual acuity was not recorded. The latest available data on 78 operations performed by the fulguration method permit me to list 38 in the successful group and 40 in the unsuccessful group. There were 5 patients for whom the immediate result was satisfactory but whose retinas again became detached within 3 months. These are now listed here as unsuccessful operations. The total count of cases classified as I have reported them here is not truly indicative of the final result of the operation. It may, however, be possible to formulate from a review of these cases a basis on which to select those patients who will have a more favorable prognosis and to evaluate modifications in the technical procedure to be used. As long as surgeons continue to operate for detachment in instances of detachment associated with other major changes such as advanced myopia, diabetes, arteriosclerosis, choroiditis, multiple retinal tears, and various changes caused by vascular disease, the proportion of successful operations for detachment will remain low.

Judged by the standard of maintenance of previous visual acuity, integrity of visual fields, and re-attachment of the retina for at least 9 months after the operation, our results at The Mayo Clinic with the Gonin method of operating were all failures. With the fulguration method, 38 operations, or 49 per cent, were successful, while 40 operations, or 51 per cent, were not successful.

RESULTS OF OPERATIONS FOR DETACHMENT OF THE RETINA AT THE ILLINOIS EYE AND EAR INFIRMARY

SAMUEL J. MEYER, M.D., F.A.C.S., Chicago, Illinois

ALTHOUGH the modern surgical treatment of detachment of the retina began in 1928 following Gonin's presentation of his technique at the Amsterdam meeting of the German Ophthalmological Society, it was not until 1934 that the present methods of surgical approach were begun at the Illinois Eye and Ear Infirmary. These methods were instituted simultaneously with the reorganization of the infirmary staff, when younger and more progressive men on the attending staff became affiliated with the institution.

In 1934, we were first able to acquire a Walker diathermy unit. Previous to that time an electric cautery constituted the entire armament. In the earlier years, some of the attending surgeons loaned their Walker pin sets for infirmary use. Later we acquired a Gradle diathermy needle to use in conjunction with the Walker diathermy machine, and for the past 5 years this has been the choice method of procedure, probably due to the ease with which it can be manipulated.

The surgical management consists of a thorough study of the fundus, allowing time, if necessary, for several days' bed rest, so that the retina may flatten out if possible before surgical intervention. A rough sketch of the fundus picture is made with blue and red crayons; blue designates the detached area, and red the holes or tears present. The tear is localized as accurately as possible by direct or indirect ophthalmoscopy with the pupil maximally dilated. Pre-operative medication usually consists of a hypodermic injection of 1/6 grain of morphine sulfate, or 0.010 gram, and 1/150 grain of scopolamine hydrobromide or 0.0005 gram 1 hour before the time of operation. Anesthesia is obtained by the instillation of ½ per cent pontocaine hydrochloride at 3 minute intervals for 4 doses. The lashes are excised with scissors. A retrobulbar injection of 1 cubic centimeter of 2 to 4 per cent novocain solution is made and about 1 cubic centimeter of the same solution is injected subconjunctivally over the region of the sclera to be exposed. A speculum is inserted, and the conjunctiva is exposed in the area of the tear by means of a curved incision parallel to the limbus and 10 millimeters posteriorly. The conjunctiva is completely undermined back to the posterior part of the eyeball depending upon the exposure necessary. The underlying rectus muscles are isolated and controlled with black silk bridle sutures, or if necessary, they may be temporarily resected and held out of the way with catgut sutures which later are used to sew the muscle back in place. The latter procedure is avoided if possible, as diplopia may result later. Insulated, flat retractors are used to obtain a good scleral exposure. The cornea is moistened constantly by saline solution instillations, so that it may remain transparent and not hinder ophthalmoscopic examination during the operation for puncture orientation. The exposed sclera is thoroughly dried with cotton sponges, and multiple, non-perforating punctures are made in the region of the tear with the Gradle needle. The fundus is examined at intervals to discover whether the punctures are correctly located. They are identified as small, white, cloudy areas. If the location is correct, a barrage of non-perforating diathermy applications is made. These punctures should hit the tear, or else wall it off, and their number varies according to the size of the involved area. Several perforating punctures are then made in the most dependent portions of the detachment to allow for escape and seepage of the subretinal fluid. In the past, 1 or 2 scleral trephine openings were made and the choroid punctured with a dull-pointed instrument instead of the perforating punctures. But this method of drainage is now abandoned. If further ophthalmoscopic examination reveals the fact that the tear or tears are well circumscribed by white, cloudy areas of chorioretinitis resulting from the diathermy current, the recti sutures are removed, and the conjunctiva is sutured by a continuous black silk suture which is left untied at both ends. A 1 per cent solution of atropine sulfate is instilled and both eyes are bandaged.

The eyes are dressed daily and the pupil is kept dilated with atropine. Absolute bed rest is imperative with the site of the perforating punctures in a dependent position. The bandages are re-

From the Illinois Eye and Ear Infirmary.
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TABLE I.—AGE OF PATIENT AT OCCURRENCE OF RETINAL DETACHMENT

Age in years	Cases	Age in years	Cases
10 to 19	17	50 to 59	44
20 to 29	15	60 to 69	16
30 to 39	14	70 to 80	10
40 to 49	24		

moved on the fourteenth day, and the patient is given hole spectacles and allowed up about the eighteenth day.

One hundred seventy histories were examined and these included all cases of retinal detachment admitted to the infirmary from 1934 to 1939. Thirty cases had to be excluded because they were too recent to be included in this series. The total reported consists of 140 patients with 148 eyes involved. In 68 the left eye was involved, in 64 the right eye, and in 8 both eyes.

Ninety-three cases occurred in males and 47 in females. The male preponderance is probably due to the greater hazards that the male sex is exposed to.

The age of the patients at the time of occurrence of the detachment is revealed in Table I. The greatest percentage of cases occurred in the decade between 50 and 59 years of age (Fig. 1). This can be explained partially by the fact that at this age many of the vascular changes and degenerations that the human organism is prone to have already become firmly established. At this period arteriosclerosis, hypertension, etc., are already present. Peripheral, senile, degenerative chorioretinitis in the region of the ora serrata is usually seen at this age. Many believe that these degenerative factors are indirectly related to the etiology of the so called idiopathic retinal detachment. The number of cases occurring in the fifth decade is also increased on account of the presence of aphacia, as 14 per cent of our cases were present in aphacic eyes. The average age was 37.8 years.

The length of time that the detachment was present when the patients presented themselves to the clinic is shown in Table II. The greatest number came for treatment between 2 to 6 weeks and 3 to 6 months after the onset of symptoms.

TABLE II.—AGE OF DETACHMENT

Age of detachment	Cases	Age of detachment	Cases
1 to 13 days	16	19 to 23 months	1
2 to 6 weeks	33	2 years	11
1½ to 2½ months	15	3 years	4
3 to 6 months	37	4 to 5 years	3
7 to 9 months	11	6 to 7 years	2
10 to 12 months	8	12 to 14 years	2
13 to 18 months	4	20 years	1

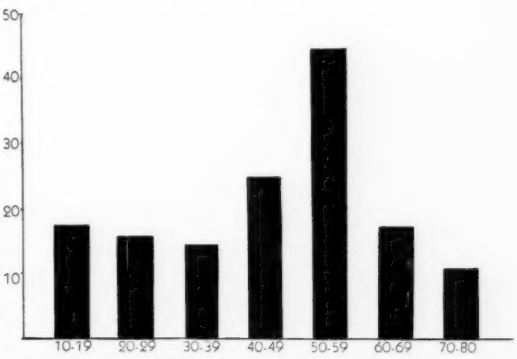

Fig. 1. Graph showing age of patient at occurrence of retinal detachment. Vertical figures represent number of cases; horizontal figures, age of patients in years.

There was a history of trauma in 32 cases or 21 per cent. Perforating injuries occurred in 2 patients. Previous surgical operations on the affected eyes were noted in 28 cases or 19 per cent, and consisted of lens extraction, 22 cases or 14 per cent; glaucoma operations, 2 cases; magnet extractions, 2 cases; and needling, 2 cases.

Tears or holes were found in 49 cases or 35 per cent. Disinsertion was found in 5 cases or 3.3 per cent. This is a relatively low incidence, but can be explained readily by the fact that the fundi were examined mostly by the house staff; the attending men did not devote enough time for such examinations. However, on one individual service, tears were found in over 50 per cent of the cases. Gonin has taught us the importance of finding retinal tears; and while most of us probably cannot boast of 90 per cent or better success in ascertaining the presence of a tear, I am certain that tears can be found in at least 60 per cent by the average ophthalmologist if he will take enough time for a proper examination.

It is important when evaluating end-results to be careful to differentiate between anatomical and functional results, because the retina may become perfectly flat, and yet the central vision may be below 0.1 due to a large central scotoma. It is well known that this may develop from a cystic degeneration in the macular region following a re-attachment of the retina. While such a case may be heralded as a surgical cure, it still is a failure to the patient.

Anatomically, there were 30 cases or 37 per cent improved, and 51 cases or 63 per cent unimproved. By this is meant a retina which has become re-attached, is perfectly flat, and remains so.

Functionally, there were 28 cases or 34.6 per cent improved, and 53 cases or 65.4 per cent unimproved. This indicates that better than 1 out of 3 patients operated upon regained a flat retina and vision of 0.1 or better. The final corrected vision of the 28 functionally improved patients is as follows: 1 patient, vision of 1.0; 4, 0.8; 1, 0.6; 1, 0.5; 4, 0.3; 14, 0.2; and 3, 0.1.

A problem with which we have to contend is the fact that there are 6 individual services, each with its own attending surgeon and accompanying staff. Such a division of services leads to diverse and various methods of diagnosis and surgical procedure. Consequently, some services handle certain problems more efficiently and satisfactorily than others, depending upon the ability and enthusiasm of the surgeon in charge. Such a system will, therefore, result in a wide variance in end-results.

These results do not compare favorably with those published by individual clinics, such as the Weve or the Lindner Clinics. In our private practice cases, Gradle and I have succeeded in attaining successful results anatomically and functionally in approximately 60 per cent of more than 260 operations. But at the infirmary, we still feel that progress is being made, in spite of the variety of operators, including the house surgeons, the poor quality of the material to work upon, and the limitation of surgical armament, all of which result in a lower percentage of successfully cured patients.

RESULTS OF OPERATIONS FOR DETACHMENT OF THE RETINA AT THE MEMPHIS EYE, EAR, NOSE AND THROAT HOSPITAL

E. C. ELLETT, M.D., F.A.C.S., Memphis, Tennessee

THE figures at the end of this article have been carefully compiled to show the results of operations for retinal detachment performed at the Memphis Eye, Ear, Nose and Throat Hospital from 1928 to 1939 inclusive, which covers the period in which Gonin's ideas and operations and the modifications of the operation he proposed have been put into practice.

The early publications by Gonin were so vague as to details that it was not possible for me, at least, to understand what he did, until a personal interview at the Amsterdam Congress in 1929 enlightened me. The first operation was a scleral puncture, accompanied by linear cauterization of the sclera. It was a failure. The next operations were ignipunctures with an electric cautery—Gonin used the Paquelin cautery—and most of these were failures, as were the cyanide of mercury injections after the method of Surdille, of Nantes. With the adoption of the diathermy operation of Larsson, Safar, and Walker we began to get better results. We have not withheld operation from any one who wanted it, no matter how hopeless, especially if the patient was poor. While this has made our statistics very poor in comparison with others, we have obtained a few brilliant results. A one-eyed, 16 year old negro girl was improved from ability to perceive light to a vision of 6/6, by 4 operations, 2 scleral punctures and 2 ignipunctures.

All compilers of hospital statistics are chagrined to find essential details omitted from many case histories. This has prevented a complete report on our work. The operation which is now done at the Memphis Eye, Ear, Nose and Throat Hospital is practically the same with all operators. The detachment is studied with a widely dilated pupil, especially for its extent and for the presence of tears or a disinsertion. Careful transillumination is done to try to detect a tumor; but if the detachment is not fresh and if it is extensive, a comparatively small tumor is sometimes overlooked, as occurred in this series 4 times. Elaborate measurements of the site of the tear and such aids as protractors and sutures to assist in this are not in common use, nor have I seen them used elsewhere. Sometimes a pin is introduced at an early stage of the operation and the relation of

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it to the tear observed with the ophthalmoscope, but as a rule we plan our operation beforehand and proceed with that plan. Study of the eye ground during the operation in a room not completely dark and with a disturbed and often distorted cornea has not helped us any in proportion to the time it takes.

The operation as a rule consists in a wide circle of contact diathermy applications, with a Larsson tip, a Gradle needle, or a LaCarrére instrument. The latter is open to the objection that the sclera is perforated and fluid runs out which permits the ball to collapse. The tear or disinsertion is then surrounded with Walker pins and the sclera punctured or trephined to draw off the interretinal fluid. We do not like to apply suction to draw off this fluid.

We are not agreed or satisfied as to the length of time necessary to keep a patient in bed or immovable after the operation. We vary the position according to the location of the detachment, and most of these patients have been kept flat in bed for 1 or 2 weeks; movement, especially of the eyes, is restricted as much as possible for a month or 2 longer.

The technique of the operation and after-care needs to be standardized. We do not attempt from this small number of cases to say how it is best done.

The number of patients in this series was 88, including 53 males and 35 females. One hundred thirty operations were performed, 28 tears and 11 disinsertions were found. The causes of detachment were as follows: myopia, 8; trauma, 24; tumor, 4; no cause was given in 51 cases. The types of operation employed were cautery to the sclera, 5; ignipuncture, 23; injection of mercuric cyanide, 3; diathermy, 95; and sclerotomy, 4. The visual results were: 33 improved, 48 unimproved or worse, 8 with a vision of 6/9 or better, and 7 were not recorded. There was full restoration of the visual field in 19, improved in 29, and unimproved or worse in 58. Anatomically, there was total re-attachment in 22, improvement in 12, no improvement in 47, and no record of anatomical results in 7 patients.

SYMPOSIUM: RESPIRATORY DISEASES

THE TREATMENT OF THE ACUTE OR RECENT PULMONARY ABSCESS

GEORGE J. HEUER, M.D., F.A.C.S., New York, New York

PULMONARY abscess continues to be a serious and ofttimes fatal malady. To me the most significant fact which emerges from a study of this disease is that in spite of a great increase in our knowledge of its etiology, of the perfection of methods used in its diagnosis and localization, of the application of improved supportive measures, and of presumed advances in the technique of its treatment, the mortality attending it remains discouragingly high. It is a disturbing fact and demands an explanation. One wonders whether the disease itself has gradually increased in its severity, thus nullifying the improvements in our treatment; or whether our present methods of treatment are wrongly conceived, or if sound whether they are poorly applied.

My experience in the treatment of pulmonary abscess may be divided roughly into two periods; an earlier period which terminated, perhaps, around 1920; a later period which has continued to the present time. In the earlier period the concept of a pulmonary abscess handed on to me by my predecessors was a simple one, namely, that it was an abscess much like an abscess elsewhere in the body. The ideas concerning its treatment also were simple. Like abscesses elsewhere, surgical drainage should be established as soon as a positive diagnosis had been made. It was, then, a period of straight-forward, surgical therapy based upon what is usually a sound surgical principle. It was also a form of therapy concurred in by the internist, who, on making a positive diagnosis, placed the responsibility for treatment in the hands of the surgeon. There are records of the results of the treatment of pulmonary abscess during this period.

The second and later period has witnessed not only a great increase in our knowledge of the etiology, pathology, and diagnosis of pulmonary abscess but also the introduction of new methods of treatment. The observation that pulmonary abscess may undergo spontaneous cure led to the introduction by Garvin of postural drainage as a method of treating pulmonary abscess; and in a paper on pulmonary abscess published early in 1922, I reported my first case of cure by this method. There followed the introduction of bronchoscopy, of artificial pneumothorax, and of phrenicectomy in the treatment of the earlier abscesses; of thoracoplasty, cautery pneumonectomy, and pulmonary lobectomy in the treatment of the older, refractory, and complicated abscesses. Intravenous and vaccine therapy also were introduced and seemed, at first, to offer promise in certain groups of cases. Surgical drainage which occupies the key position in the treatment of the acute abscess in the earlier period, was supplanted by the more conservative methods and has come to occupy a position on the side lines to be called back upon the field only when conservative methods fail. The opinion often expressed that surgical drainage, if used in the treatment of the acute abscess, results in disaster, is now quite generally accepted in spite of some observations in the early period contrary to that opinion. The relation of the internist and surgeon has changed. With the introduction of conservative methods of treatment, the internist, who previously transferred the responsibility of treatment to the surgeon, has assumed this responsibility to a greater or lesser extent, and is treating the condition often without sufficiently early surgical consultation.

That the treatment of pulmonary abscess, after the enormous effort of this second period, can be viewed with something distinctly less than satisfaction is, perhaps, sufficient justification for again examining into methods of treatment. In doing so I shall call upon my own experience and the experience of others as reported in the literature. I shall confine myself to the single or soli-

From the Department of Surgery, New York Hospital and Cornell University Medical College.

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tary abscess occurring in one or more lobes, and shall leave out the consideration of multiple abscesses from whatever cause. I shall confine myself still further to the treatment of the acute or recent abscess, for I believe this to be the essence of the problem.

Perhaps I had best begin by reviewing very briefly the pathological and clinical course of pulmonary abscesses as we observe them in patients in our hospital wards. It is a composite picture I wish to present, one which portrays the history of an abscess from its inception to its late stages or termination. Pathologically, it begins as an area of consolidation in the lung which in time undergoes liquefaction. Usually the liquid pus is evacuated through a bronchus; and after this primary evacuation a pulmonary abscess is a cavity within the lung without a visible or palpable wall. On more than one occasion I have inserted my finger into such a cavity; its boundaries feel soft and velvety and fail to give to the palpating finger any sense of resistance greater than that of pulmonary tissue. An abscess in this stage of its evolution collapses at once and completely after the evacuation of its contents, and often will heal with astonishing rapidity if opened surgically. If measures directed toward its cure in this stage fail, a series of pathological events may occur. A rapidly spreading pneumonitis or gangrene of the lung may develop sooner or later in the course of the disease which will terminate the life of the patient. A rigid and increasingly heavy, fibrous wall may be laid down about the cavity which tends to defeat efforts directed toward its obliteration. The inflammatory process may extend from the original abscess to the parietal pleura which gives rise to empyema or pyopneumothorax. Erosion or invasion of the surrounding blood vessels by the inflammatory process may occur and cause hemorrhage or, through septic embolism, brain abscess. Periodic attacks of bronchopneumonia, if not fatal, may be followed by softening of the areas of consolidation causing multiple abscesses about the original one; and associated fibrosis may lead to local bronchial dilatation and eventually cause a condition of chronic pulmonary suppuration which is hopeless from the viewpoint of treatment save by cautery pneumonectomy or pulmonary lobectomy.

Clinically, the manifestations of this disease parallel its pathological evolution. The early symptoms before liquefaction of the abscess has taken place are well known together with those accompanying the sudden evacuation of pus through the bronchus and those which supervene during the transition from a condition of acute inflammation to one of subacute or chronic sepsis. So, too, the more serious manifestations associated with a spreading pneumonitis have been observed: periodic attacks of bronchopneumonia, single or repeated massive hemorrhages, empyema and pyopneumothorax, and brain abscess. I have no doubt all have seen patients in the stage of chronic pulmonary suppuration one or more years after the onset of the acute abscess. These are tragic individuals who arouse the pity and often defeat the best efforts of the surgeon.

In hospital practice it is possible to observe patients in every phase of the pathological evolution of pulmonary abscess which I have just reviewed. The experience gained by observing and treating them makes it quite evident that the various pathological conditions which may develop from the early abscess are largely responsible not only for the difficulties in treatment but also for the high mortality in this disease. It also teaches us that the course of an abscess often cannot be predicted accurately from clinical symptoms; for repeatedly it happens that a patient whose clinical course has been reasonably satisfactory, suddenly or insidiously develops one or another of the serious complications I have described which may terminate life. For these reasons the most important single problem in the treatment of pulmonary abscess is its prompt cure in its acute or early stage. It is a statement of fact which my own experience and the experience in the literature suggests is frequently disregarded both by physicians and surgeons.

In the treatment of the acute or recent abscess at the present time the almost universal practice is to use conservative or palliative methods combined with supportive treatment. The conservative methods include postural drainage, bronchoscopic treatment, artificial pneumothorax, and phrenicectomy or phrenic nerve crushing. The rationale of the first two is to promote adequate drainage through a bronchus and so effect a cure without the necessity of external surgical drainage. The rationale of the second two is to obliterate the abscess cavity through the collapse of the lung. I shall attempt again to evaluate these methods both from my own experience and from the experience of others.

1. Conservative therapy. My experience with conservative methods is best illustrated by a study of the New York Hospital series. Between the years, September, 1932, and September, 1939, 100 patients with pulmonary abscesses were admitted to the surgical wards. Two patients were admitted in a moribund condition and died untreated; 24 patients had multiple pulmonary

abscesses which, as I have said, will be excluded from consideration; and 10 patients had pulmonary abscesses secondary to carcinoma of the lung in 8 or carcinoma of the esophagus in 2. These I also exclude. There remain 64 patients. Of these, 55 were believed to have uncomplicated solitary abscess and were treated primarily by conservative methods, while 9 were admitted with abscess complicated by pyopneumothorax and were treated primarily by surgery.

In the 55 patients with presumed uncomplicated solitary abscess the conservative measures used were almost exclusively postural drainage supplemented occasionally by bronchoscopic treatments. Previous experience led me to believe that little is to be expected from the more frequent use of bronchoscopic methods, artificial pneumothorax, or phrenicectomy, that well supervised postural drainage does not offer. One patient in this series was given artificial pneumothorax and promptly developed empyema, and 1 patient was subjected to phrenicectomy without benefit.

Of the 55 patients treated conservatively, 26 appeared to be making favorable progress and no other more radical treatment was employed. Of these 26 patients, 16 recovered and are at present well; 10 failed to recover and I believe are now dead. Of the 10 supposedly dead, 7 are known to be dead and 3 are most probably dead. The 3 left the hospital against advice unimproved, with abscesses still present, and cannot be traced. A study of the patients who died shows that they developed untoward symptoms rather suddenly which made impossible the application of other more radical measures. Five patients during the course of conservative treatment developed a fatal spreading pneumonitis, 1 developed multiple brain abscesses, and 1 meningitis. The results of our conservative treatment, limited to this group, show that 61.5 per cent of our patients recovered and 38.5 per cent died.

While 26 of the 55 patients appeared to respond favorably to conservative therapy, 29 patients did not. At variable times after conservative measures had been tried, these patients were subjected to surgical drainage. The total results, including late follow-up studies, show that 19 or 65.5 per cent are well and 10 or 34.5 per cent are dead. Among the dead are 2 patients who at autopsy had multiple abscesses, only 1 of which had been drained.

Summarizing this experience I might say that in a selected group of 55 patients with pulmonary abscesses 26 were treated by conservative methods of whom 61.5 per cent recovered and 38.5 per cent died; and 29 were treated by surgical drainage of whom 65.5 per cent recovered and 34.5 per cent died. But with reference to the results of conservative treatment such a statement, I think, is misleading, for it does not take into account the cases which failed to respond to conservative measures. Would not a more correct statement of the results of our conservative measures be that they succeeded in 29 per cent and failed in 71 per cent of our patients and that 29 per cent of cures were achieved at the cost of an 18.1 per cent mortality?

It is difficult to form an estimate of the value of postural drainage from reports in the literature. Some authors base their results on the condition of the patient at the time he leaves a service or at she time of discharge from a hospital. Others fail to take into consideration anywhere from 30 per cent to 60 per cent of the cases in which postural drainage is unsatisfactory and which are transferred to surgery or elsewhere. Such reports fail to give a true picture of the results of postural treatment. Again, not a few authors have used tuccessively or together a number of methods as postural drainage, bronchoscopic treatments, artificial pneumothorax, and phrenicectomy. It is impossible in these to evaluate the results of a single method. A review of the literature shows that postural drainage is reported to have achieved satisfactory results in from 20 per cent to 80 per cent of the cases; the majority, perhaps, show 50 per cent or better. But when I analyze these reports from the viewpoint of the total number of patients subjected to this form of therapy, I conclude that 25 to 30 per cent represents a generous average of the satisfactory results which have been attained. The unsatisfactory results are even more difficult to appraise. Based upon total numbers subjected to this form of therapy, the mortality varies between 13.5 and 36 per cent and averages 24.8 per cent in 6 large series of cases. This statement does not, however, give the whole story for it leaves out the consideration of a chargeable secondary mortality following surgery in patients treated too long by postural drainage and a consideration of late complications which occur after the patient has been discharged from the clinic. Nor do the reports generally published take into account, even if fatalities are averted, the long period of hospitalization and the secondary and successively more serious operations performed. I would say, then, that a fair appraisal of postural drainage as a method of treating pulmonary abscess is that it achieves 25 per cent satisfactory results at the cost of a 25 per cent mortality.

2. *Bronchoscopy.* I have never considered bronchoscopic treatments as a method *per se* in

the treatment of pulmonary abscess but rather as an adjunct to other methods. As an adjunct, bronchoscopy is particularly valuable in contributing to the accurate localization of abscess, in the differential diagnosis between simple abscess and abscess secondary to carcinoma of the lung, in determining the presence of a non-opaque foreign body, and in establishing and dilating, for the purpose of better drainage, a bronchial stenosis or partial occlusion proximal to an abscess. As a method of treatment it has been employed only occasionally rather than routinely, and when used it has been for the purpose of assisting postural drainage.

Perhaps in my own cases I have minimized the importance of bronchoscopy as a method of treatment. In the literature there are favorable reports from the use of the method. Flick, Clerf, Funck, and Farrell found that of 161 patients with pulmonary abscess treated medically, bronchoscopically, or surgically, 50.3 per cent recovered, 29.8 per cent were improved, 5 per cent were unimproved, 1.2 per cent recurred, and 13.7 per cent died. An unusually high percentage of their 172 patients were treated bronchoscopically. Of the 127 so treated, 6 were still under treatment at the time of the report. Of 121 patients in whom bronchoscopic treatments had been employed and completed, 54 per cent recovered, 13 per cent were improved, 6 per cent were unimproved, 23 per cent were referred to surgery, and 2.4 per cent died. Kernan found that of 103 patients with pulmonary abscess, 68 had 3 or more bronchoscopic treatments. Of the 68 patients, 45.5 per cent were cured, 22 per cent were improved, and 13.2 per cent died. Four patients were still under treatment and 9 could not be traced. Allen and Blackman collected 650 cases from the literature in which bronchoscopic drainage was, in their opinion, the principal form of treatment. Of the 650 patients, 61 per cent are reported as well, 20 per cent as improved, 12.5 per cent as unimproved, and 6 per cent as dead. Of the larger series of cases these are the best results which have been reported and, indeed, they appear impressive. Other reports are not so favorable and a mortality rate as high as 20 per cent to 25 per cent has been reported following the use of the method. Those with the largest experience point out that the early abscesses and particularly the abscesses following tonsillectomy respond most favorably to this method of treatment.

It is always difficult to evaluate a method which forms not the sole but a part of the treatment of a condition. Bronchoscopy is used in conjunction with postural drainage and with the purpose of securing more adequate drainage. To what extent it has contributed to the success of non-surgical drainage cannot be stated dogmatically. Its greatest successes have been obtained in cases in which postural drainage alone is most likely to succeed; and it does not appear to have contributed greatly in cases in which postural drainage has failed. Although I have reviewed the literature since my last paper on pulmonary abscess, my attitude toward bronchoscopy remains the same, namely, that it occupies an important but still a secondary rôle in the treatment of the acute or recent abscess; and that it should be utilized only when the services of an expert bronchoscopist are available.

3. Artificial pneumothorax. With this method I again have little personal experience for I have never been convinced that its application to pulmonary abscess was sound therapeutics. It was introduced as a method of treating pulmonary abscess because of its success in the treatment of pulmonary cavitation incident to tuberculosis. The 2 conditions are not similar nor are the objectives of treatment the same. There is little doubt that patients with pulmonary abscess have recovered after the use of artificial pneumothorax but a review of the literature shows that little is to be expected from the method in the treatment of this condition. In Miller and Lambert's last series of 40 cases it was used in 10 in conjunction with rest and posture. One patient recovered, 2 were improved, and 7 were not improved and were referred to surgery. King and Lord in 210 cases attempted to use it in 22. In 6 patients collapse failed, in 4 partial collapse was obtained, and in 12 complete collapse. Of the 16 patients in whom partial or complete collapse was obtained, 1 recovered, 3 were improved, 9 were unimproved and referred to surgery, and 3 died. There are many more reports in the literature which I might quote and many opinions of men who have had experience in the treatment of abscess. It would appear that as a method it has proved unsatisfactory. It has a limited field of application; it not infrequently fails to achieve its purpose, and it is attended by the danger of empyema or pyopneumothorax.

4. Phrenicectomy or phrenic nerve crushing. As a method, phrenicectomy also must be considered as an adjunct to postural drainage. Reports in the literature regarding its value are conflicting. Allen and Blackman used it in 26 of 100 cases and in conjunction with postural drainage and other conservative measures. Of the 26 patients 12 recovered, 3 were improved, 10 unimproved, and 1 died. Of the 13 improved or unimproved 10

were referred to surgery. Lueth in a series of 101 cases treated 8 patients by this method. Six were improved and 2 died. King and Lord treated only 2 of 210 patients by this method of which 1 was not improved and 1 died. Many other reports of small numbers of patients treated by this method occur in the literature. I think it can be said that thus far the application of this method has been limited and that the results obtained have not been striking.

5. Surgical drainage. As stated earlier, surgical drainage at the present time is not often a primary but a secondary method of treating pulmonary abscess. Generally speaking it is now reserved for what, from the viewpoint of treatment, are the undesirable groups of pulmonary abscess: the abscesses in which conservative measures have failed, the chronic abscesses with thick rigid walls, the abscesses complicated by empyema and pyopneumothorax, and so forth. In these unfavorable groups of cases it has achieved a certain measure of success; and in my own experience at the New York Hospital surgical drainage in a distinctly less favorable group, including all patients with pyopneumothorax, yielded only slightly less favorable results than postural drainage.

It is not, however, its present field of application which I wish to discuss but a reconsideration of its use in the treatment of the acute or recent abscess. A comparison of my latest with my earliest experience in the treatment of pulmonary abscess is interesting in this connection. If I exclude from both series the multiple abscesses due to generalized infections and those due to primary malignant disease of the lung and esophagus, there remain 64 cases in the New York Hospital series and 44 in the Johns Hopkins Hospital series. As a result of the treatment of these two groups of patients 60 per cent of the New York Hospital series recovered and 40 per cent died; while in the Johns Hopkins Hospital series 80 per cent recovered or were improved and 20 per cent died. An examination of the methods employed shows that in the New York Hospital series 55 of the 64 patients were treated primarily by conservative methods, 9 patients whose conditions were complicated by pyopneumothorax, were treated primarily by surgery, and subsequently 29 patients were treated secondarily by surgery. In the Johns Hopkins Hospital series 3 of the 44 patients were treated primarily by conservative methods, 41 by surgery, and subsequently 1 of the total number was treated secondarily by lobectomy. These findings suggest that the better results obtained in the early series were due to a more consistent use of surgical methods in the acute or recent abscess. A comparison of the results of surgical drainage in the 2 series suggests further that surgical drainage may be expected to give better results in the acute abscess than in the later more refractory abscess. If I include in both series 11 patients who presented the complication of pyopneumothorax or had multiple abscesses only 1 of which had been drained, surgical drainage in 38 patients in the New York Hospital series resulted in the recovery of 57.9 per cent and in the death of 42.1 per cent of the patients; in the Johns Hopkins Hospital series recovery or improvement resulted in 71.4 per cent and death in 28.6 per cent of the patients, which includes 1 death from lobectomy. If I exclude from each series the 11 patients who presented the complication of pyopneumothorax or had multiple abscesses, only 1 of which had been drained, in other words, if I confine myself to the uncomplicated solitary abscess, surgical drainage in 27 patients in the New York Hospital series resulted in the recovery of 70.4 per cent and in the death of 29.6 per cent of the patients. In the Johns Hopkins Hospital series 24 patients or 95.8 per cent recovered or were improved and death occurred in 4.2 per cent of the patients. I wish to point out that the results as I have just reported them are not quite comparable. Those for the New York Hospital are, I believe, accurate for they include almost complete follow-up studies; those for the Johns Hopkins Hospital series may not be wholly accurate for in some cases the late follow-up records are lacking. But in those in which such late reports are lacking, the favorable condition on discharge leads me to believe that the large majority recovered.[1]

This from my own experience is evidence in favor of surgical drainage as a primary or early treatment of the acute or recent abscess. Further evidence is the changing viewpoint of a number of observers who have studied the subject intensively and who are gradually shortening the period of conservative treatment in favor of earlier surgical drainage. Most impressive is the experience of Neuhof and Touroff who have reported two series of cases, the first including 37, the second 45 patients with pulmonary abscess. Their viewpoint of the treatment of the acute early abscess differs from that underlying the present common practice. They do not advocate the treatment of every acute abscess by surgical drainage; but they believe, as a result of their experience, that an increasing number of pul-

[1]Other evidence in the New York Hospital series supports this belief. Of 7 patients discharged from the hospital "improved" and with a good prognosis, 6 have recovered; 1 died 2 years after discharge from brain abscess.

monary abscesses should be treated in the acute stage of the disease by surgical drainage. Of 45 patients treated by surgical drainage in the acute stage, 40 or 89 per cent are well, 3 or 6.6 per cent are improved, and 2 or 4.4 per cent have died. There is much in these two publications which should be studied seriously by physicians and surgeons.

SUMMARY AND CONCLUSIONS

I have reviewed the pathological and clinical course of pulmonary abscess. It is a disease characterized during its course by the occurrence of unusually fatal complications including pneumonitis, gangrene of the lung, bronchopneumonia, pyopneumothorax, pulmonary hemorrhage, and brain abscess. If one follows the life history of 100 patients with pulmonary abscess treated by present methods, he finds happily that a certain number recover; but unfortunately he sees patient after patient drop from the list due to these complications. In addition he observes in patients, who have failed to recover promptly but who have escaped death, the development of a chronic stage of the disease with abscesses surrounded by heavy rigid walls, with secondary multiple abscesses, and with abscesses associated with bronchiectasis. An entire lobe of the lung becomes involved in the chronic suppurative process; and in an effort to relieve the patient of an intolerable condition he must perform successively larger and more serious operations which carry with them a high mortality. Even those who survive are by no means always cured; for he finds in follow-up studies that some eventually die from chronic sepsis, brain abscess, or pneumonia. The total results of present methods of treatment in our hands, based upon 100 patients, is that 60 recover and 40 die; but it is to be added that the results probably would not have been so good had we treated 100 instead of 64. Cutler and Gross have followed 90 patients. Of these 53 are well and 35 have died; but the eventual outcome of the 13 patients listed as improved and the 9 unimproved or not followed remains problematical. I think, on the basis of my own experience and my review of the literature, that I would err on the side of optimism were I to conclude that 50 of every 100 patients treated by present methods die of the disease.

In a search for the reasons for these unsatisfactory results I have confined myself to the present commonly accepted treatment of the condition, leaving out a consideration of the factors which undoubtedly influence the outcome of the disease. The most serious fault with the treatment lies in the failure to cure the acute abscess promptly. I have reviewed the conservative methods now used in the treatment of the acute or recent abscess. I have ventured also to re-emphasize surgical drainage as a radical method of treating this condition. From a study of these conservative and radical measures I have formed opinions.

The therapeutic value of rest and supportive measures including blood transfusions cannot be doubted and these measures form a not unimportant part of the treatment of pulmonary abscess. Artificial pneumothorax and phrenicectomy appear to have added little to the therapeutics of the disease, and, in my opinion, might well be discarded in the treatment of the acute or recent abscess. Bronchoscopy has proved to be a valuable aid in the diagnosis and localization of abscess; and it may be of service in securing better drainage by postural methods. Postural drainage finds its greatest usefulness in the treatment of the smaller acute abscesses with relatively mild symptoms such as those following tonsillectomy; but as a method applied in the treatment of all acute or recent abscesses, it leaves much to be desired. The fault seems to lie in two directions: in an improper selection of cases for its use and in its too prolonged use. My own experience and the experience of others would indicate that in the large acute abscesses with highly toxic symptoms, postural drainage is sometimes inadequate to meet a situation which surgical drainage may control. Its too prolonged use invites the dangerous complications which contribute in greatest measure to the mortality. It is a mistake to believe that these are late manifestations, and, therefore, one may safely proceed with postural drainage. In the New York Hospital series, 40 per cent of the total deaths in those treated by postural drainage occurred within 2 months after the onset of symptoms. Of 9 cases of pyopneumothorax in the series, 4 occurred within the same period of time. Rives, Major, and Romano, in an analysis of the causes of death in 100 consecutive fatal cases, found that spreading pneumonitis was the greatest and pyopneumothorax the second greatest cause of death. In 88 of the 100 fatal cases the duration of illness is known; and of these it was more than 1 month's duration in less than half the cases and more than 3 months' duration in less than one-fifth of the cases. Could the occurrence of these serious complications be foretold by the clinical course of the disease, they might be averted by resorting to other methods of treatment. However, they cannot always be foretold.

Surgical drainage as a method of treating the acute or recent abscess should be restudied seri-

ously. It was replaced by conservative methods because of early reports of its high mortality. It is interesting to reread these early reports. In a paper published in 1919, Frederick T. Lord reported the results of treatment of 100 cases. Of these, 38 were not subjected to operation and 24 died or a mortality of 63 per cent, while 14 were alive or untraced at the time of the report. Of the 14 alive, 7 recovered spontaneously and 7, when last seen, continued to cough and expectorate. Sixty-two of the 100 patients were subjected to operation, of whom 35 died in the hospital or a mortality of 56 per cent. But when one considers the patients subjected to operation he agrees with Lord that 29 of the 35 deaths occurred in patients already doomed before operation was undertaken. They were patients with multiple abscesses, an associated pneumonia, brain, liver, and subphrenic abscesses, carcinoma, general sepsis, and advanced myocardial disease. Only 6 deaths occurred in 33 patients without these fatal complications. In an early study of the treatment of pulmonary abscess published in 1922 I found that of 24 patients with uncomplicated abscess treated by surgical drainage in the acute stage of the disease only 1 patient died, leaving a mortality rate of 4.2 per cent. Whittemore in a study of his second series published in 1921 reported a 5.8 per cent mortality following surgical drainage. The opinion expressed in these early reports is that it is the single abscess in its acute stage which responds most favorably to surgical drainage. The recent reports of Neuhof and Touroff would seem to confirm it.

If the above opinions were formulated into a plan for the treatment of the acute abscess, this plan would include postural drainage and surgical drainage as methods of treatment and rest, supportive measures and bronchoscopy, as important adjuncts to these methods. As soon as an abscess becomes recognizable as such, which it usually does in 5 to 10 days after the onset of symptoms, postural drainage and surgical drainage would be considered as competitors in its treatment and not as 2 methods of which the latter is supplemental to the former. The idea that surgical drainage, if employed early, must necessarily result disastrously is rejected in this plan; rather it is considered a method which may save lives if promptly used. The idea that postural drainage may be used safely over prolonged periods is abandoned. Instead the period of its use is shortened possibly to a month after the onset of symptoms unless striking results are obtained. Its early abandonment in favor of surgical drainage is considered advisable even with the knowledge that some patients will be subjected to operation who might eventually be cured without it; for it is a viewpoint which has proved sound in other acute conditions. Such a plan implies a closer relationship between physician and surgeon, first rate diagnosis, accurate localization, keen judgment, and a high degree of surgical skill.

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CURABILITY OF PRIMARY CARCINOMA OF THE LUNG

Early Recognition and Management

RICHARD H. OVERHOLT, M.D., F.A.C.S., Boston, Massachusetts

TOTAL excision of the lung and resection of mediastinal lymphatic structures represent surgery's contribution to the treatment of primary malignancy of the lung. A wave of enthusiasm naturally followed the reports of initial successes with pneumonectomy. Interest in carcinoma of the lung as a practical clinical problem has been stimulated. In the majority of cases the diagnosis is now being made in the living subject rather than having its presence revealed for the first time at autopsy. However, from many sources in this country and also Europe, one cannot help but sense a feeling of disappointment in the paltry number of operable cases discovered.

Must we, during the next 30 years, anticipate a gloom as deep as that felt by those who have been through 30 years with the surgical treatment of carcinoma of the stomach? Ogilvie, in an address before the Clinical Congress in 1938 said, "Upon the subject of cancer of the stomach we can look only with gloom. The operability in cases of patients presenting themselves with symptoms is lower than with any other growth. The operative mortality remains much as it was 30 years ago, and is the highest of any major operation."

A number of conditions peculiar to carcinoma of the lung should favorably influence the operability rate. It is my intention to support an optimistic view. A summary of an experience in the study of 104 patients will be given. In this group 21 per cent were considered operable, and subsequent observations have shown that 14 per cent did not have an extrapulmonary extension when treatment was instituted. The survival rate among patients successfully treated without gross evidence of mediastinal extension shows a low rate of recurrence. Based on present knowledge and strides already made, one may predict a steadily increasing cure rate in primary carcinoma of the lung.

Before any progress in early diagnosis can be made, it is essential that the profession as a whole be interested in the problem, that the lesion produce a warning symptom which will induce the patient to seek advice, and that there be methods available for proving or disproving histologically the presence of cancer. All these prerequisites may be brought into play in the early discovery of primary lung malignancy.

From the New England Deaconess Hospital.

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BASIS OF OPTIMISM

1. Interest. In the first place, the general medical profession will soon become conscious of the great importance of cancer of the lung as an entity because it is a common disease. A condition which kills approximately 15,000 people a year in the United States, a disease which has been shown to be the cause of death in over 1 per cent of all patients examined at autopsy, and to represent 10 per cent of all cancer deaths will force the profession generally to take cognizance of it.[1] Furthermore, in the past it was difficult to persuade the profession at large to become interested in a disease that was invariably fatal. Now the dampening effect of incurability has been removed.

2. Early warning symptoms. The growth in three-fourths of all primary lesions is situated within a stem bronchus thereby causing disturbances before the growth attains any great size. This probably occurs early in the clinical course of the disease. Irritation of the sensitive bronchial mucosa in this region results in a dry irritative cough; 88 per cent of the author's series produced this symptom. The cough is persistent and fails to respond to usual remedies. The character of the cough is such that medical advice is likely to be solicited. This early warning symptom focuses attention on the lung just as the development of indigestion or a change in bowel habits points the diagnostic finger toward the stomach or colon.

Hemoptysis is an alarming symptom which almost invariably will bring the patient under medical observation; this occurred in 38 per cent of the author's series. During the early stages of partial bronchial occlusion, wheezing or an asthmatic type of breathing may be noted. The severity of the disturbances that follow complete bronchial obstruction depends upon the size of the

[1] The most reliable source of data on the relative frequency of fatal disease comes from autopsy material of general hospitals where admissions are unselected. The above figures are based on a study of 52,305 recently collected autopsy reports made by Overholt and Rumel (13).

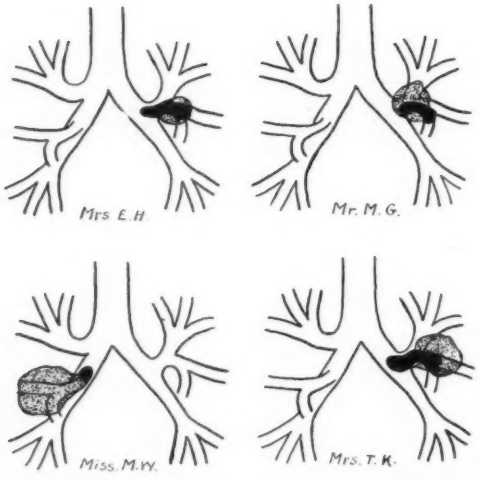

Fig. 1. Outline of stem bronchi in 4 cases of operable bronchiogenic cancer based on bronchoscopic findings and gross surgical specimens. Intrabronchial portion is solid black; extrabronchial portion, shaded. Mrs. E. H., age 45. The tumor originated in the lateral inferior wall of the left upper lobe bronchus and projected well into the lumen. Carcinoma simplex; glands not involved. Patient is now well, 5 years and 1 month after left pneumonectomy (Figs. 5, 6 and 7). Mr. M. G., age 45. The tumor was an annular growth involving the left upper lobe bronchus. Occlusion was not complete. Epidermoid carcinoma, grade II; 1 hilar gland involved; mediastinal glands negative. Patient is well and working 3 years and 3 months after left pneumonectomy. Miss M. W., age 18. Lesion originated in right middle lobe bronchus with intrabronchial projection and extrabronchial growth. Adenocarcinoma. Patient is living and well 8 months after right pneumonectomy. Mrs. T. K., age 45. Tumor originated in left upper lobe bronchus 1 centimeter from bifurcation. Two-thirds of the tumor was growing outside of bronchus. Small cell carcinoma; glands not involved. Patient is living and well now 2 years and 5 months after left pneumonectomy.

TABLE I.—CARCINOMA OF THE LUNG: SUMMARY OF 104 CASES OBSERVED IN 6 YEAR PERIOD*

Biopsy material source	No.†	Operation type	No.	Operative recovery No.
Autopsy	6	Bronchoscopic‡		
Bronchoscopy	56	fulguration	1	1
Biopsy	3			
Pleural fluid	0	Lobectomy	4	3
Sputum	1			
Exploration	15	Pneumonectomy	17	11

*In this group 23 cases were unverified histologically; 81 yielded tissue for diagnosis, and 22 were accepted for surgical treatment.

†All proved carcinoma. Reports by Shields Warren. Benign tumors, metastatic lesions, and sarcoma have been excluded.

‡Small lesion in right lower lobe bronchus in a patient 33 years of age. Miss M. N. Biopsy revealed small cell carcinoma of low grade malignancy. Bronchoscopy and treatment by Dr. W. B. Hoover, who reports that the patient was well and free of evidence of disease 3 years and 11 months later.

TABLE II.—RESULTS OF THORACIC EXPLORATION FOR PRIMARY MALIGNANCY IN 52 SUSPECTED OR PROVED CASES

Pre-operative diagnosis	No.	Extrapulmonary extension of tumor found No.	Resection Lobectomy No.	Resection Pneumonectomy No.
Verified	26	13	0	13
Unverified	26*	14†	4	4

*Carcinoma was suspected but not found upon exploration in 4 patients. Before thoracic exploration these 4 cases were grouped among those in whom a presumptive diagnosis of carcinoma of the lung had been made. Since this diagnosis was disproved, they have not been included in the group of 104 cases reported. Notation of them is made to show how often cancer was not found upon exploration when suspected before.

†Tissue was obtained for diagnosis in 7 cases, and not obtained in 7 cases; upon resection malignancy was found in 8 patients.

bronchus involved and upon the presence or absence of an associated infection. A heavy ache or sense of constriction in the chest or even dyspnea may be experienced fairly early as a result of a relatively small growth occluding a first or second division bronchus. Fever and other constitutional effects of infection may also appear early and thereby bring the patient under observation while the obstructing lesion is relatively small. Fifty-three per cent of patients in this series had fever on admission.

Symptoms referable to the lung did attract attention to the chest of every patient in the author's series except 2, or 98 per cent. In the great majority of the inoperable cases chest symptoms antedated those due to metastatic disease by several months or years.

3. Availability of chest roentgenograms. Not only the desirability but the absolute necessity of roentgenograms to aid in diagnosis of pulmonary lesions is being appreciated more generally. The early diagnosis campaign now being waged by phthisiologists throughout the entire country and their dependence on chest roentgenograms have done much to educate the profession to this diagnostic necessity. Furthermore, cough, hemoptysis, or other pulmonary symptoms frequently direct patients to sanatoria or tuberculosis clinics. From this source alone many early lesions should be discovered.

The density of the lung structure lends itself to roentgenographic contrasts better than any other visceral organ. Furthermore, a small lesion which is strategically located in the bronchial lumen will give early telltale evidence of its presence by producing either an area of emphysema due to partial obstruction, an atelectatic shadow due to complete obstruction, or both. In the event that the lesion originates in one of the smaller bronchi in the periphery of the lobe, which was the case in 25 per cent of the author's series, it

TABLE III.—THEORETICAL CURE RATE AS BASED ON A STUDY OF 100 CASES*

	Cases
A. Patients showing extrapulmonary extension—	
Metastasis upon clinical examination..... (Includes cases first diagnosed at autopsy)	62
Rejected because of age or poor general condition..	4
Metastasis found at exploration.....	14
Operative deaths—autopsy revealed metastasis....	3
Late deaths—autopsy revealed metastasis..... (1 pneumonectomy 2 lobectomies)	3
Total	86
B. Patients showing no extrapulmonary extension—	
Operative deaths—autopsy revealed no metastasis. (2 pneumonectomies, 1 lobectomy)	3
Late death in successfully treated patient, autopsy showing no metastasis.....	1
Postoperative patients living and well without evidence of metastasis (one patient treated by bronchoscopic fulguration).....	10
Total	14

*Two apparently operable patients who refused operation were omitted. Also, freedom from extrapulmonary extension could not be positively determined in 2 patients without autopsy who died following operation. These 2 patients have also been excluded in the above table.

will not produce atelectasis at an early stage, but the tumor itself will cast a shadow. In the past it has been the discrete shadow of a peripheral type tumor that was more likely to be detected than the small bronchus-occluding tumor that produced no direct shadow of the tumor itself but merely an atelectatic shadow. An excellent description of roentgenographic changes in the lung fields resulting from bronchial obstruction has been given by Westermark.

4. Accessibility of the tumor to visualization and biopsy. It has already been said that three-fourths of the tumors originate in the major bronchi. Most of these can be visualized bronchoscopically and will yield tissue for microscopic study. In our series of verified cases, 62 were of the stem bronchus type. Fifty-nine patients in this group were examined bronchoscopically and a positive biopsy obtained in 56 instances. In view of the fact that many laryngologists and most thoracic surgeons are skilled in carrying out this essential diagnostic procedure, bronchoscopic facilities are available in most centers throughout the country. Bronchoscopy has now become so much a matter of routine in many general hospitals and sanatoria that there is little hesitancy on the part of physicians to recommend it, or of patients to submit to it.

CARCINOMA OF THE LUNG—A SURGICAL PROBLEM UNTIL PROVED OTHERWISE

There is general agreement as to the most effective method of handling patients suspected of harboring malignancy of abdominal viscera.

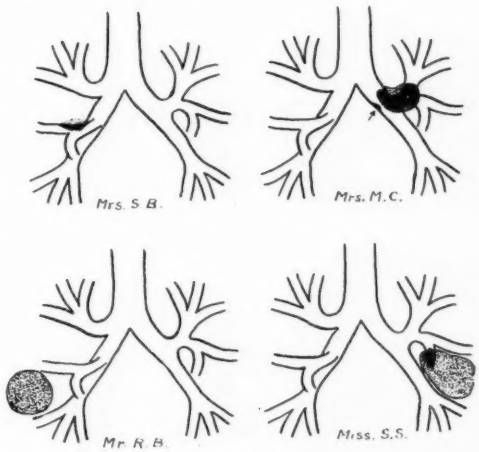

Fig. 2. Outline of stem bronchi in 4 cases of operable bronchiogenic cancer. Mrs. S. B., age 45. Tumor originated in secondary bronchus of right middle lobe and was the smallest growth in the entire series. The lesion produced atelectasis of 1 segment of the middle lobe (Fig. 4). Adenocarcinoma; glands not involved. Patient is living and well 1 year and 11 months after right pneumonectomy. Mrs. M. C., age 59. Tumor originated in left upper lobe bronchus, extended principally into the lumen. An implant of the tumor was found on the medial wall of the main stem bronchus. Carcinoma simplex; glands were not involved; operative recovery; late death from other causes after 7 months. Autopsy failed to reveal evidence of recurrence. Mr. R. B., age 53. Tumor originated in periphery of right lower lobe but could not be visualized bronchoscopically. Adenocarcinoma; lobectomy; mediastinal glands not involved. Patient is well without evidence of recurrence 1 year and 10 months later. Miss S. S., age 53. Tumor originated in lingual branch of left upper lobe and could not be seen bronchoscopically. Adenocarcinoma; diagnosis verified at operation. Patient is now well without evidence of recurrence 1 year and 5 months after left pneumonectomy.

Such patients are considered surgical problems until the question of operability is settled, as excision provides the only hope for cure. Cancer of the lung should and must be considered in the same category. The surgical issue is frequently forced in cancer of the digestive tract by obstruction. Malignant bronchial obstruction does not demand surgical intervention so dramatically, but without its help the lesion that produces the obstruction is, in the end, as fatal as untreated intestinal obstruction due to malignancy.

Surgery versus radiation. Resection of the lung has been of such recent development that the policy of giving radiation a trial even without histological verification is the course too often followed. At the present state of our knowledge

TABLE IV.—DURATION OF SURVIVAL AFTER SUCCESSFUL RESECTION OF LUNG FOR PRIMARY CANCER*
Collected Series

Case no.	Surgeon	Age of patient	Preoperative duration of symptoms mos.	Location of tumor**	Lobes involved †	Histology	Type of operation‡	Date of operation	Living without evidence of metastasis, last date	Living with metastasis, last date	Date of death	Cause of death
1	W. E. Adams	58	9	S	L.U.	Squamous cell	P	Feb. '38	Nov., '38		Nov., '38	General peritonitis, gangrenous appendix
2	Idem	42	4	S	R.M.	Squamous cell	P	Jan. '37	Aug., '39			
3	R. C. Brock	50	12		L.L.	Oat cell	P	Mar. '39	Aug., '39			
4	H. Brunn	39	12	S	R.M. & L.	Cancer of the lung	L	Nov., '38	Aug., '39			
5	A. Ceballos	54	24	P	L.L.	Bronchus epithelioma	L	Nov., '35	Aug., '36	Sept., '36	Oct., '36	Pulmonary hemorrhage
6	Idem	50	1	P	R.L.	Early cancer	L	Nov., '36	Sept., '39			
7	Idem			P		Epithelioma	L	May, '37	Oct., '37		Dec., '37	Recurrence in mediastinum
8	E. D. Churchill	54	12		R.L.	Bronchus epidermoid	L	Apr., '35	May, '39			
9	Idem	57	6		L.L.	Bronchus epidermoid	P	Apr., '36			June, '38	Metastasis
10	Idem	39	6		R.M.	Bronchus epidermoid	P	May, '37	Sept., '39			
11	Idem	60	12		R.L.	Bronchus epidermoid	L	May, '34			June, '35	Cerebral metastasis
12	Idem	58	12		R.L.	Adenocarcinoma	L	Jan., '36			Apr., '36	Widespread metastasis
13	Idem	43	6		R.L.	Adenocarcinoma	P	Oct., '36	Jan., '39			
14	Idem	38	12		R.M.	Adenocarcinoma	L	July, '36	Feb., '39			
15	Idem	44	6		L.L.	Adenocarcinoma	L	Aug., '34			Dec., '34	Generalized metastases, including brain
16	Idem	41	6		R.U.	Bronchus epidermoid	P	May, '39	Sept., '39			
17	F. S. Dolley and J. C. Jones	48	4	S	R.L.	Cancer	P	Jan., '37	Aug., '39			
18	Idem	48	3	S	L.L.	Cancer	P	Jan., '39	Aug., '39			
19	Idem	52	5	P	R.M.	Cancer	P	May, '39	Aug., '39			
20	S. O. Freedlander	40	4	S	R.L.	Adenocarcinoma	P	Aug., '36	Apr., '37	July, '37	Apr., '38	Pleural recurrence, rt; metastasis to left lung
21	Idem	33	8	S	L.U.	Adenocarcinoma	P	Feb., '38	Sept., '39			
22	H. K. Gray	43	2	S	L.U.	Adenocarcinoma grade II	P	Sept., '37	Sept., '39			
23	Idem	46	3	S	R.L.	Adenocarcinoma grade I	P	Sept., '38			Dec., '38	Multiple abscesses in left lung; right empyema
24	Idem	45	?	S	R.U.	Adenocarcinoma gr. IV	L	May, '39	Sept., '39			
25	J. Holst	45	12	P	U	Cancer	L	Feb., '36	Jan., '39			
26	R. M. Janes	40		P	R.U.	Cancer actively growing	L	Feb., '36			July, '36	Cerebral metastasis
27	Idem	32	8	S		Epidermoid cancer	L	July, '38	June, '39			
28	Idem	52	12	S		Anoplastic cancer	L	Oct., '38	Aug., '39			
29	R. Nissen	48	36	P	R.L.	Epidermoid cancer	En.	June, '36	Feb., '39			

TABLE IV.—DURATION OF SURVIVAL AFTER SUCCESSFUL RESECTION OF LUNG FOR PRIMARY CANCER*—Continued

Collected Series

Case no.	Surgeon	Age of patient	Preoperative duration of symptoms mos.	Location of tumor**	Lobes involved †	Histology	Type of operation‡	Date of operation	Living without evidence of metastasis, last date	Living with metastasis, last date	Date of death	Cause of death
30	R. Nissen	69	4	S	R.U.	Small cell cancer	L	Dec., '35	Mar., '36	?	?	? metastasis
31	W. R. Rienhoff	26	18	S		Adenocarcinoma	P	Nov., '33	1939			
32	Idem	69			L		P	Jan., '35			Apr., '35	Metastasis to brain
33	Idem	44	6	S	L	Squamous cell cancer	P	Mar., '35	1939			
34	Idem	47			R.U. & R.L.	Alveolar cell cancer	P	Aug., '35			Feb., '36	Metastasis to mediastinum
35	Idem	65	18		R.L.	Adenocarcinoma	P	Apr., '36			Sept., '36	Recurrence in pleural cavity
36	Idem	50	12	S		Adenocarcinoma	P	Dec., '36			1938	Metastasis to right lung
37	Idem	50				Squamous cell cancer	P	Feb., '37	1939			
38	Idem	62	4		R.M.	Adenocarcinoma	P	Oct., '38			May, '39	Coronary thrombosis ? metastasis
39	Idem	58		S	R		P	Oct., '38	1939			
40	Idem	65		S		Squamous cell cancer	P	Mar., '37	1939			
41	Idem	45	6	S	R	Squamous cell cancer	P	Apr., '37	1939			
42	Idem	48	6	S	R		P	Nov., '37	1939			
43	Idem	50	12	S	R.U.	Squamous cell cancer	P	Sept., '38	1939			
44	Idem	64		S	L	Squamous cell cancer	P	Mar., '39			Sept., '39	Primary cancer of colon, not associated with primary cancer of lung
45	Idem	40		S	R.L. & M.	Squamous cell cancer	P	July, '39	1939			
46	Idem	30		S	R.L. & M.	Squamous cell cancer	P	July, '39	1939			
47	J. E. Strode	55		P	L.L.	Cancer	P	June, '37	Feb., '39			
48	J. Alexander & C. Haight	39	48	S	R.L.	Adenocarcinoma	P	Mar., '35	Sept., '39			
49	Idem	38	3	S	L.U.	Squamous cell cancer gr. III	P	Sept., '36			Jan., '39	?
50	Idem	55	2	P	L.U. & L.	Medullary cancer grade IV	P	Mar., '37			Aug., '37	Pneumonia, probable metastasis in spine, no autopsy
51	Idem	17	8–12 ?	S	L.U.	Adenocarcinoma, gr. I	P	Apr., '37	June, '39			
52	Idem	41	10	S	R.L.	Squamous cell grade II	P	Feb., '38	Mar., '39			
53	Idem	55	4	P	L.U.	Medullary cancer grade III	P	July, '38		May, '39		
54	Idem	58	6	S	L.U. & L.	Medullary squamous cell	P	June, '39	Sept., '39			
55	Idem	53	24	P	L.L.	Papilliferous ¶ cystadenocarcinoma § grade II	L	Mar., '37			Nov., '37	Recurrence—multiple

TABLE IV.—DURATION OF SURVIVAL AFTER SUCCESSFUL RESECTION OF LUNG FOR PRIMARY CANCER*—Concluded

Collected Series

Case no.	Surgeon	Age of patient	Preoperative duration of symptoms mos.	Location of tumor**	Lobes involved †	Histology	Type of operation‡	Date of operation	Living without evidence of metastasis, last date	Living with metastasis, last date	Date of death	Cause of death
56	F. L. Conklin	47	2	P	R.U.	Adenocarcinoma	P	Feb., '39			July, '39	Primary carcinoma right lung with metastasis to right chest wall
57	Idem	46	6	S	R.M.	Adenocarcinoma	P	Aug., '38	Sept., '39			
58	R. F. Bowers	52	6	S	L.L.	Epidermoid cancer	P	July, '37	Oct., '39			

Author's Series

Case no.	Surgeon	Age of patient	Preoperative duration of symptoms mos.	Location of tumor**	Lobes involved †	Histology	Type of operation‡	Date of operation	Living without evidence of metastasis, last date	Living with metastasis, last date	Date of death	Cause of death
1	R. H. Overholt	33	4	S	R.U. L.M.	Cancer unclassified	P	Nov., '33	Sept., '39			
2	Idem	45	4	S	L.U.	Cancer simplex	P	May, '34	June, '39			
3	Idem	59	24	S	L.U.	Cancer simplex	P	Aug., '35			Mar., '36	Psychosis, autopsy negative for malignancy
4	Idem	45	5	S	L.U.	Epidermoid cancer	P	May, '36	Aug., '39			
5	Idem	56	1	S	L.U. & L.	Oat cell cancer	P	Sept., '36			Feb., '37	Metastasis to liver
6	Idem	45	48	S	L.U.	Small cell cancer	P	Jan., '37	June, '39			
7	Idem	45	13	S	R.M.	Epidermoid cancer	P	June, '37	May, '39			
8	Idem	51	6	S	R.L.	Epidermoid cancer grade II	P	Nov., '37			Jan., '39	Pneumonia, no autopsy
9	Idem	53	1	P	R.L.	Adenocarcinoma	L	Dec., '37	Sept., '39			
10	Idem	53	12	P	L.U.	Adenocarcinoma	P	Apr., '38	Sept., '39			
11	Idem	34	12	P	L.U.	Cancer simplex	P	May, '38	July, '39			
12	Idem	18	11	P	R.M. & L.	Adenocarcinoma	P	Jan., '39	Sept., '39			

*All patients showing mediastinal glandular involvement or other evidences of extrapulmonary extension at the time of operation, or patients dying within three months of operation, have not been included.
**S, stem bronchus; P, peripheral.
†Lobes involved: R or L—right or left; U, upper; M, middle; L, lower.
‡P, pneumonectomy; L, lobectomy.

there should be no dispute about recommendations for patients suffering from cancer confined solely to the lung. In a perusal of the literature on the subject I find not a single supporter for the use of either deep roentgen or radium therapy in the so called operable case. Radiologists are in agreement that most primary bronchiogenic tumors are highly radioresistant. The results of such treatment have been disappointing although there is an occasional rare exception. Cure by radiation has never been claimed. Graham states that he has not been able to find record of a single authenticated 5 year cure. Edwards and Brock and Cann, each of whom has had a large experience in the use of intrabronchial radon implantation, do not recommend radiation in any

form for the operable lesion. There is no justification for delaying a decision regarding operability until roentgenotherapy has been tried.

It is beyond the scope of this paper to discuss the management of the inoperable case. However, it has been our experience that not infrequently the ill effects of roentgenotherapy overshadow its benefits. In the presence of superimposed infection, roentgenotherapy often aggravates symptoms and may actually do the patient harm. In 13 patients so treated the average duration of life was 5.6 months; whereas in 26 cases in which no treatment was given, the average survival from diagnosis to death was 8 months. At the present time we are giving radiation only to those inoperable lesions which are causing severe pain and those which do not show evidence of an associated pulmonary suppuration.

Immediate decision regarding operability is essential. In the reported series of cases in which the diagnosis was made during life, the interval between the first symptom and death was relatively short. In the series reported by Jaffé, the period extended approximately 5 months. Koletsky reported 8.9 months, and Frissell and Knox 7.5 months. In our own series, the average interval from the first appearance of symptoms to diagnosis was 11.6 months. It is obvious that time is an important factor. The first steps should be immediate diagnostic tissue verification and evaluation of operability. Both of these steps are surgical. Therefore, carcinoma of the lung is a surgical disease until proved otherwise.

DIAGNOSTIC PROCEDURES

Abnormal physical signs associated with early pulmonary malignancy are either absent or are so variable that they lack significance. The signs in stem bronchus lesions are essentially those of bronchial occlusion or of a superimposed infection. Chest roentgenograms have already been referred to as important in furnishing presumptive evidence. Bronchography may be helpful in cases in which the lesion is beyond the range of bronchoscopic visibility. A bronchial defect may be demonstrated and the relation of the suspicious area to all segments of the lung may be shown more clearly.

Before recommending thoracic exploration for suspected malignancy it is highly desirable that tissue be obtained and the diagnosis verified histologically. Three possible methods of obtaining tissue from the primary lesion are available:

1. *Bronchoscopy* has yielded tissue for biopsy in 72 per cent of all cases examined by this method. Since the majority of lesions are found within the range of bronchoscopic visibility, this procedure becomes the most important diagnostic method at our disposal. Two other reasons make bronchoscopy invaluable. First, a diagnosis can be made

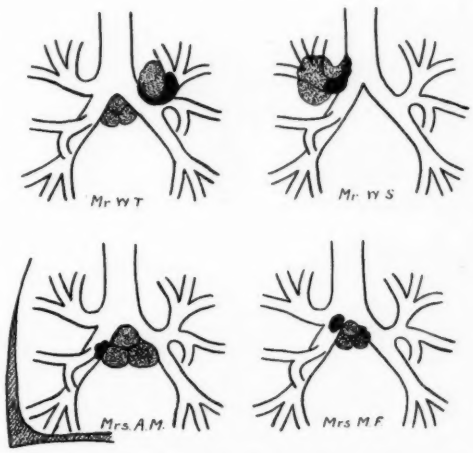

Fig. 3.—Outline of stem bronchi in 4 cases of inoperable bronchiogenic cancer. Mr. W. T., age 41. Carcinoma simplex, grade II; carina widened; fixation left main stem bronchus. Mr. W. S., age 44. Tumor originated in right upper lobe bronchus with extension up the wall of trachea. Epidermoid, grade II. Mrs. A. M., age 62. Carcinoma simplex. Originated in medial wall of right lower lobe bronchus; mediastinal gland enlarged; trachea fixed; pleural fluid contained malignant cells. Mrs. M. F., age 47. Lesion originated in left lower lobe bronchus with extension of growth through to right lower lobe bronchus. Carcinoma simplex.

TABLE V.—LATE SURVIVAL AFTER SUCCESSFUL RESECTION OF LUNG FOR PRIMARY CARCINOMA*

Author's and collected cases (Summary of Table 4)
70 patients

	Lobectomy		Pneumonectomy		Total	
	No.	Per cent	No.	Per cent	No.	Per cent
Living	10	56	35	67	45	64
Living with metastasis	0	0	1	2	1	1
Died of metastasis	8	44	11	21	19	27
Died of other causes	0	0	5	10	5	8
Total	18	100	52	100	70	100

*Benign tumors, sarcoma, or metastatic malignancy have not been included. Cases showing mediastinal glandular involvement at operation and patients dying within 3 months of operation have been omitted.

Longest survival without evidence of metastasis—5 years and 9 months; 19 patients have lived over 2 years.

Average postoperative period of living cases—1 year and 11 months.

Fig. 4. Roentgenogram in early case of primary carcinoma situated in right middle lobe bronchus. The area of density below and lateral to the hilum was caused by atelectasis in 1 segment of the middle lobe. The tumor here was not over the size of a lima bean and failed to cast a shadow distinguishable from the atelectatic shadow. See diagram of Mrs. S. B. in Figure 2. Bronchoscopy positive. Lesion—epidermoid carcinoma. Right pneumonectomy performed June, 1937.

earlier by this method than by any other. A lesion too small to occlude the bronchus and produce roentgenographic changes may be seen bronchoscopically. Second, it is by far the safest method of securing a biopsy in stem bronchus lesions (Figs. 1 and 2).

2. *Examination of the sputum for malignant tissue.* When bronchoscopy fails to provide tissue, a careful search of the sputum for malignant cells may be fruitful. Dudgeon and Wrigley and later Barret described a wet-film method which led to a correct diagnosis of pulmonary malignancy in 20 of 26 cases, all verified by autopsy. By using Dudgeon and Wrigley's technique, Dr. W. R. Rumel and Dr. Shields Warren have found malignant cells in the sputum of several proved cases of carcinoma in the author's series. It has not been possible to classify the cells as to type. Although these examinations have been made routinely during the past year, the test has been of practical value to us in only 1 case. Other times when malignant cells were found in preparations from sputa, the lesions were inoperable or tissue for biopsy had been obtained bronchoscopically. From our experience so far with this method we are led to believe that the high incidence of diagnostic verification found by Dudgeon and Wrigley was due to the large number of far advanced cases coming under their observation. Whether examination of the sputum for malignant cells will become valuable in the very early cases remains to be determined.

3. *Tissue obtained by thoracentesis and lung puncture.* The experience of Craver and Binkley in aspiration biopsy of lung cancer has recently been published. It is difficult to be convinced that this method is practical in the operable case. A positive aspiration in such a case calls for surgical exploration. A negative aspiration does not disprove cancer, and therefore thoracic exploration is also indicated. Needling the tumor transpleurally cannot be devoid of danger, as suppuration of the involved lung is a common associated condition. A dissemination of the infection might complicate the situation enough to preclude safe resection. One patient came to us with an empyema which followed repeated attempts at thoracic aspiration. This complication was a determining factor in the patient's inability to survive pneumonectomy.

EVIDENCES OF INOPERABILITY

Before rendering a verdict of "inoperable," one would prefer to have histological verification that the growth has invaded tissues outside the lung. This is not possible in many instances. The following criteria for inoperability have been used:

A. Rejected on bronchoscopic evidence. (1) Frozen mediastinum as determined bronchoscopically, unless fixation is interpreted as being due to previous disease. Widening of the carina, *per se*, is not positive evidence of malignant involvement of glands within the bifurcation. In 1 of our cases a mass of enlarged glands which widened the carina did not contain tumor cells but was inflammatory. It must be admitted, however, that most patients who show widening of the carina do have involved mediastinal glands (Fig. 3, Mr. W. T.); (2) tracheal extension which occurred 3 times in our series (Fig. 3, Mr. W. S.); and (3) implantation of growth in contralateral bronchus (1 patient), (Fig. 3, Mrs. M. F.).

B. Rejected on roentgenographic evidence. (1) Bilaterally widened mediastinal shadow as shown by roentgenogram with obvious glandular involvement. Unilateral intensified hilar shadow or enlarged hilar glands are found so frequently in operable lesions that they do not necessarily spell inoperability. Usually a paralyzed diaphragm means mediastinal infiltration with involvement of the phrenic nerve. A paralyzed diaphragm was

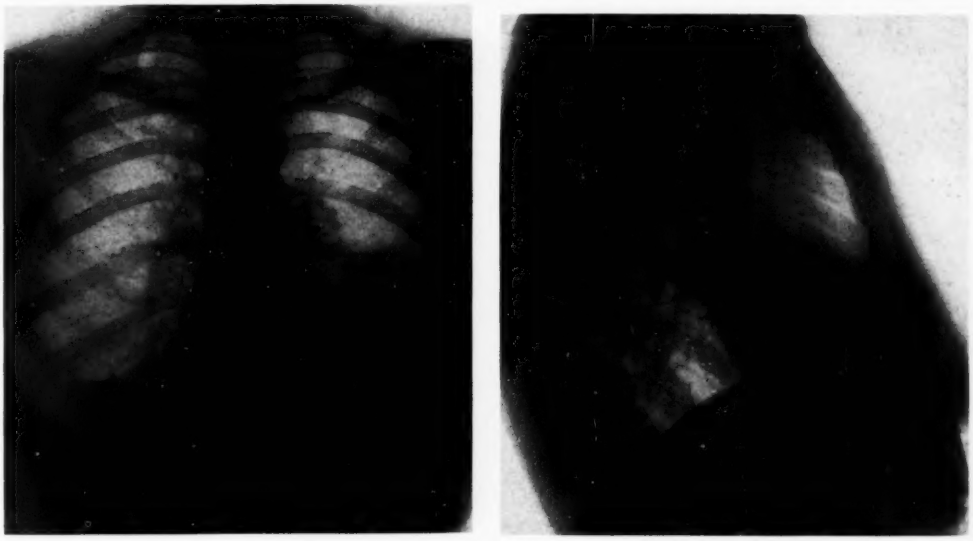

Fig. 5. Roentgenograms in early primary carcinoma involving the left upper lobe bronchus at the point of its division. The lingual branch was completely occluded and other branches partially so. See diagram, Mrs. E. H. in Figure 1. Note emphysematous character of portion of upper lobe with atelectasis of lingual portion shown best in lateral exposure. The bronchoscopic examination was positive, the biopsy showing carcinoma simplex. Left pneumonectomy was done in May, 1934. Over 5 years after operation was performed the patient is living and well. (From Overholt and Rumel (13). Courtesy of publishers of J. Lancet.)

found in 1 patient coming under observation who died from the effects of pulmonary suppuration. The autopsy showed no involvement of the phrenic nerve by the malignant process. (2) Metastasis to bones, as found in skeletal roentgenograms. Solitary lesions of questionable identity have been biopsied if accessible. In 1 patient surgery was almost denied because of supposed metastasis to a rib. Tumor cells were not found in the biopsied rib. Pneumonectomy was carried out and the patient has lived 5½ years and is still well.

C. Rejected on discovery of distal malignant cells elsewhere. (1) Cervical glands positive on biopsy; (2) malignant cells in aspirated pleural fluid. Usually pleural effusion develops in the later stages and is a bad omen (Fig. 3, Mrs. A.M.). Pleural fluid was found in but 1 operable case in our series; and (3) pleural metastasis demonstrated by thoracoscopic examination. It is significant that the operability rate in this series has been higher than in any other reported series of cases, yet the average duration of symptoms is longer. The duration of the first symptom to diagnosis was 15.6 months in the operable group, and 11.5 months in the entire series. This emphasizes the importance of a thoracic surgical evaluation of operability.

It is frequently difficult to appraise the patient's general condition due to constitutional effects of an associated infection in the lung. Prolonged fever and weakness resulting from pulmonary suppuration need not necessarily contra-indicate operation. Frequently, improvement can be effected by bronchoscopic dilatation and improved internal drainage. Gradual deflation of the lung by a preliminary period of pneumothorax may greatly enhance a patient's chance of withstanding pneumonectomy. It must be remembered that the excision of tumor also removes the septic reservoir entirely, thereby ridding the host of both conditions.

However, some patients may also be considered inoperable on the basis of insufficient pulmonary reserve. A small tumor producing a "ball-valve" effect in a stem bronchus may reduce the vital capacity to the point of dyspnea at rest. Emphysema of an entire lung is not tolerated as well as the loss of the lung itself. Periodic dyspnea due to bronchospasm induced by the irritation of the tumor may also be misleading in an appraisal of ability to tolerate pneumonectomy.

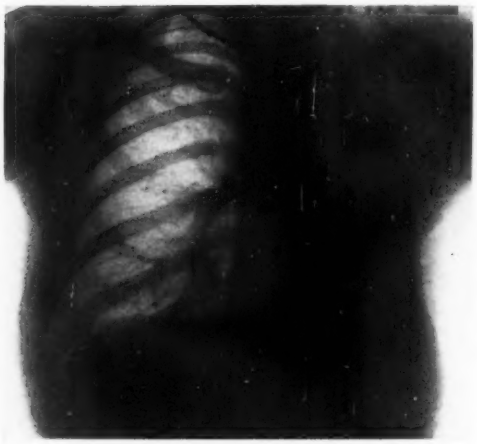

Fig. 6. Roentgenogram of chest (Mrs. E. H.) 5 years and 1 month after left pneumonectomy. Note density and diminished area of left hemithorax. Thoracoplasty was not performed. (Overholt (12). Courtesy of publishers of J. Connecticut State Medical Society.)

RESULTS OF CLINICAL EXAMINATION AND DISPOSITION OF CASES

During the past 6 years 104 patients have been studied in whom a diagnosis of primary malignancy of the lung has been made. Fifty-one or practically one-half of the total number were free of clinical evidence of metastasis when coming under observation. One patient was treated by bronchoscopic fulguration; 2 patients refused thoracic exploration; 48 patients were explored and 21 were found suitable for resection. This places the operability rate at 21 per cent for the entire group which includes both verified and suspected cases. Operability in the group verified histologically, even including those in whom the disease was determined for the first time at autopsy, was 27 per cent.

In Table I certain data concerning the entire group is summarized. It seems encouraging that it was possible during life to obtain tissue for histological verification in 92 per cent of the verified group and in 72 per cent of the entire group. Tissue was not obtained until after death in 6 cases and the disease was suspected in 4 of these. Two patients, 1 with brain tumor and 1 with pericardial invasion, died after presenting symptoms referable only to metastatic disease. Our experience, therefore, is much more encouraging than that of Hochberg and Lederer who state that 21.7 per cent of their patients came under observation with initial symptoms attributable to metastatic disease.

In Table II are summarized the results of thoracic exploration in 52 patients in whom

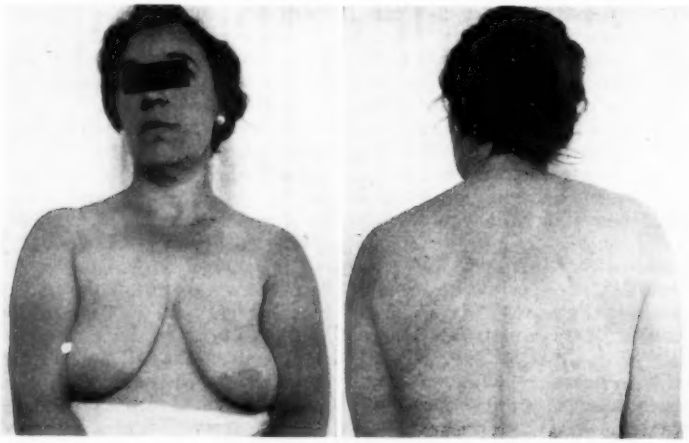

Fig. 7. Photograph of Mrs. E. H., now age 50. Left pneumonectomy was performed in May, 1934, for carcinoma simplex involving left upper lobe bronchus (Figs. 1, 5, and 6). When examined on June 28, 1939, patient reported that she was symptom free since leaving the hospital, had not spent a day in bed because of illness, and was doing all her own housework. Note lack of deformity and general state of nutrition. (Overholt (12). Courtesy of publishers of J. Connecticut State Medical Society.)

primary malignancy was suspected or verified. There were 26 patients in each group. In 13 of the verified cases exploration revealed extrapulmonary extension and the operation was concluded. In 1 other patient mediastinal involvement was determined after resection. Operability in the verified group was therefore 46 per cent rather than 50 per cent. Fourteen patients in the unverified group were considered unsuitable for resection after exposure of the hilum and mediastinum. In 7 instances it was possible to obtain tissue from the lung or mediastinum for diagnostic confirmation. In an equal number it was considered unsafe to remove tissue for microscopic study. These patients remain in the unverified group.

One of the most difficult problems confronting the thoracic surgeon presents itself during exploration in cases of suspected malignancy when one's decision regarding pneumonectomy is not fortified by previous tissue diagnosis. This situation arises chiefly in regard to the peripheral type of neoplasm. It has been considered safer to rely upon clinical features, gross appearance, and palpation rather than to resort to biopsy of the primary lesion during exploration. Pneumonotomy or even attempts at aspiration are likely to result in contamination of the hemithoracic space and mediastinum which is a complication definitely to be avoided in the safe performance of pneumonectomy. In 8 instances a lobe or an entire lung was removed on presumptive evidence alone and carcinoma was found in all removed specimens. In exploring the chests of 4 patients in whom a presumptive diagnosis of carcinoma had been made, other conditions were found and corrective surgical treatment was given. Two cases of extensive pulmonary suppuration, thought to be engrafted upon a malignant process, were successfully treated by pneumonectomy. One patient who developed a dry irritative cough with attacks of hemoptysis was found to have a solitary mass in the mid-lung field resembling a peripheral type of neoplasm. Exploration revealed a deeply situated interlobar empyema which healed following drainage. Another patient had chronic cough, pulmonary hemorrhages, and an atelectatic upper lobe, which developed sometime after a streptococcus sore throat and pneumonia. The roentgenogram was typically that of a stem bronchus carcinoma with upper lobe atelectasis. Exploration revealed evidences of a postinflammatory fibrosis of the upper lobe with constriction at the hilum. Mobilization of the upper lobe and release of scar above the hilum was followed by a disappearance of all symptoms and a re-expansion of the lobe.

Eleven of the 17 patients treated by pneumonectomy and 3 of the 4 treated by lobectomy survived the operation. Two of the latter have since died of recurrences. Both of these patients were treated early in our experience, and pneumonectomy would have been the procedure selected for them if they had come under observation at a later time. One patient treated by lobectomy is still living without evidence of recurrence 1 year and 8 months since the operation.

Survival rates among the group treated by pneumonectomy have been better. One patient died of recurrence 4 months after operation and 2 other patients have since died but not of cancer. In 1 patient autopsy failed to reveal any trace of recurrence. Another patient was examined 10 months after operation and no evidence of recurrence was discernible, but a few weeks later pneumonia developed which terminated fatally. Postmortem examination was not done.

Survival rates do not necessarily tell the whole story nor does the percentage of cases accepted for surgical treatment. A theoretical cure rate for this group was computed by subtracting all those cases subsequently shown to have had metastasis, whether manifest at operation or not, and by adding operative deaths in which it was shown at autopsy that metastatic disease was not present. This computation is shown in Table III. It has been found that 14 per cent of the total number of cases did not have extension of the growth beyond the lung at the time surgical treatment was instituted.

Nine patients, 1 a lobectomy case and 8 pneumonectomies, who once suffered from primary malignancy of the lung, are now living and well without evidence of recurrence. Activities have not been restricted and all but 2 patients are carrying on with the same work previously done. Two patients have passed the 5 year mark and another is in his fourth year (Figs. 5, 6, 7, and Table IV).

The rather low incidence of recurrence in those patients surviving pneumonectomy seems definitely encouraging. Since insufficient time has elapsed for the experience of any one individual to reach significant proportions, all surgeons who have reported on the successful performance of pneumonectomy for carcinoma were sent a questionnaire concerning follow-up data. The questionnaire was answered by 23 surgeons. The collected data on reported and personal cases are shown in Tables IV and V. The questionnaire related only to patients who were free from mediastinal glandular involvement or other evidences of extrapulmonary extension at the time of

operation, and to those who survived for more than 3 months after operation. A total of 58 cases was included in the responses to the questionnaire. Summarizing collected data and our own experience, we found that 45 of a total of 70 patients are still living and free of disease. Nineteen patients succumbed to metastatic disease. In 5 patients death was reported to be due to other causes. Of the 19 who died of metastatic disease, 8 followed lobectomy. It is significant that in the pneumonectomy group of 52 cases, only 11 patients have since died of recurrence. The survey reveals that 64 per cent of all patients who were treated before the advent of metastasis and who survived operation have continued to live for variable periods of time up to 5½ years without evidence of recurrence.

SUMMARY

1. The medical profession should become interested in primary carcinoma of the lung, first because it is a common disease, and second because curative treatment is available to those whose disease is still local in its extent.

2. An optimistic attitude as to the future seems justified for the following reasons: (a) Early warning symptoms do occur in the majority of cases; (b) early lesions may be suspected after roentgenographic examination, as the lung fields lend themselves well to contrasting shadows either of the tumor or of atelectasis; (c) three-fourths of all primary lung tumors are situated in the stem bronchi, and are therefore accessible to bronchoscopic visualization and biopsy.

3. In a period shorter than a decade of surgical treatment, operability has surpassed that of the esophagus and possibly the stomach. In a series of 104 cases, 21 per cent of the lesions were considered resectable and surgical treatment was carried out. The theoretical cure rate in this series of patients has been computed to be 14 per cent. Eleven per cent of the verified cases have lived following surgical resection for varying periods of time up to 5 years and 10 months without evidence of recurrence.

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POSTOPERATIVE PULMONARY COMPLICATIONS

DANIEL C. ELKIN, M.D., F.A.C.S., Atlanta, Georgia

THE appraisal of surgery by its final attainments has long claimed the attention of the American College of Surgeons. To this body should go much of the credit for the improvement of surgery in this country, through constantly stressing the value of end-result studies. Evaluation of statistical data obtained in this manner has called attention to sequelæ and complications which so often mark the difference between success and failure of an operation. All this has led to more intelligent efforts to reduce these complications by better pre-operative preparation, improvements in anesthetics and their administration, meticulous care in the elimination of operative trauma, and closer attention to the patient throughout the convalescent period.

Of all the complications which beset the surgeon, those involving the lungs are among the most common; the morbidity from this cause alone is about 3 per cent. This in itself is serious enough but is even more alarming when one realizes that about 40 per cent of those patients die. In operations upon the upper abdomen the morbidity for serious pulmonary sequelæ is about 10 per cent. Consequences of so frequent and serious a nature demand the efforts of all surgeons in bringing about methods for their prevention and cure.

Etiology. Numerous etiological factors have been proposed to account for pulmonary lesions which follow operation, and it is probable that any of these, or a combination of them, is responsible. The 2 most commonly supported views, and the 2 causing most controversy are (1) that anesthesia, with aspiration of infected material, is the cause of most pulmonary complications, and (2) that emboli, either sterile or infected, are responsible. Other factors, such as decreased respiratory excursions, abolition of the cough reflex, and a lowered resistance must be considered.

The embolic theory, which Cutler has ably advocated and frequently emphasized, is based upon well established clinical and experimental evidence. With every wound thrombosis inevitably occurs as a natural phenomenon. That thrombi sometime break off and reach the lung is to be expected. Frequently they are so small or few in number that no symptoms result. When larger emboli block the pulmonary circulation infarction occurs, and upon the size and number of the emboli and upon the amount and virulence of infected material carried with it will depend the extent and nature of the pulmonary disorder.

The fact that pulmonary complications follow operations performed under local anesthesia with almost the same frequency as those done under general anesthesia, is additional evidence of the rôle of infarction as an etiological agent. Moreover, the experimental production of pulmonary lesions by infarction is easily accomplished, while the production of pneumonia by the bronchial route is notoriously difficult. Since large amounts of infected material are aspirated with every operation under general anesthesia, it would be logical to expect a greater percentage of lung infections if this were the means by which the infection is produced. The abrupt onset in most pulmonary lesions, particularly those that occur 8 or 10 days after operation, point to the embolic nature of the disease; and the same pathogenic bacteria can be found frequently in a lung abscess as is present in a septic wound elsewhere in the body. Thus it is seen that there is a sound and logical basis for those who believe that wound trauma, and that alone, is responsible for postoperative pulmonary complications.

On the other hand, there is no doubt that infected material from the mouth and throat, as well as blood and vomitus, is drawn into the lungs of anesthetized patients. Bacteria thus implanted may be the cause of varying reactions in the lungs; this depends upon such factors as the virulence of the organism and the resistance of the host.

Whipple found the pneumococcus as the most common inciting factor in postoperative pneumonitis and type IV of this organism was most frequently found in the sputum. Lately Sutliff and Steele have confirmed these findings of a predominance of the pneumococcus in cases of postoperative lung complications and stressed the apparent relationship of pulmonary changes to the pharyngeal flora. They found that "three patients without pathogenic organisms in the pharynx before or after operation had the least lung changes," but in "thirteen patients with pathogenic organisms in the pharynx, eleven had postoperative pulmonary changes greater than the

From the Department of Surgery, Emory University.

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minimum." The findings of these and many other investigators indicate the importance of nasal and pharyngeal infection as a source of postoperative pulmonary complications.

The rôle of atelectasis in the production of postoperative lung complications is undoubtedly a large one, and it has been claimed that this lesion is the basis of these disorders. Following abdominal operations, particularly high incisions, the absence of deep diaphragmatic breathing rapidly brings about absorption of the alveolar air and collapse of the lower lobes. Thus a high, fixed diaphragm is a frequent finding after operation. Limitation of respiration by position or by tight abdominal binders and abolition of the cough reflex likewise predispose to atelectasis. The accumulation of mucus and failure to expectorate it are hastened by these conditions, and plugging of the bronchi with subsequent absorption of alveolar air results. While atelectasis may not be a precursor of pneumonia in all cases, the stage is set for invasion of the lung by bacteria, and infection of varying degrees usually follows. This is further influenced by those factors which tend to lessen the patient's resistance, such as rapid and excessive changes in temperature.

While either aspiration, emboli, or atelectasis may appear to be the predominating factor in the production of postoperative pulmonary complications, it is likely that there is an interrelation between 2 or more causative agents.

Symptoms and physical findings. Regardless of the etiology, postoperative lung disorders bear a striking similarity in their mode of onset and physical characteristics. Usually within 48 hours there is a rapid rise of temperature to 102 or 104 degrees with increased pulse and respiration. Subjective symptoms are noticeably absent which account for the frequent failures of diagnosis. Usually, the only complaint is a painful cough, malaise, and a feeling of "catching cold." Occasionally, the onset is accompanied by pain in the chest and the expectoration of bloody or rusty sputum.

At first the physical signs may be limited to the finding of râles at the lung bases, without evidence of consolidation, and a diagnosis of bronchitis is made. Roentgenograms usually show only some elevation of the diaphragm due to hypoventilation (3). This condition, which is alarming largely because of the temperature rise, usually subsides in 24 hours.

However, the process may progress with a further rise in temperature, pulse, and respiration. An area of consolidation appears, usually in one of the lower lobes, and is confirmed by the roentgenographic shadow, which is often wedge-shaped. The physical findings are those of lobular pneumonia: dullness, tubular breathing, and increased fremitus. Symptoms subside gradually, and the temperature falls by lysis, usually within 3 or 4 days. This is the usual course, but the infection may spread throughout one lung, or even to the other side, and it is in cases of this type that death is most apt to occur. Likewise infection may be of such a type, particularly if infarction is present, as to lead to abscess of the lung or gangrene. These latter conditions are but a continuation of the infectious process and are to be looked for if the cough becomes more persistent and the temperature continues beyond the time expected in ordinary bronchopneumonia. Here again roentgenograms are of the greatest value in diagnosis.

While some degree of atelectasis probably exists in most lung complications, massive collapse of a lobe or even an entire lung must be considered as a pathological entity and should not be confused with pneumonia or pleural effusion. The symptoms and physical findings are variable and depend upon the extent of lung involvement. The onset is usually sudden, 48 to 72 hours after operation. There may be pain in the chest, shortness of breath, cyanosis, and a rapid rise in temperature, pulse and respiration. The patient appears frightened, anxious, and acutely ill, or the symptoms may be so mild that the condition is not detected unless the chest is examined. The collapsed lung is dull to percussion, the breath sounds are diminished or absent, and the mediastinal organs are displaced toward the side of the lesion. The roentgenograms will assist greatly in the diagnosis, especially in those patients with incomplete deflation. The intercostal narrowing over the affected area can be compared to the normal side, and the displacement of the heart and trachea and the elevation of the diaphragm can be seen clearly.

TREATMENT

Treatment is largely directed toward prevention and elimination of the predisposing factors which lead to pulmonary complications. In general, prophylactic measures are intended (1) to prevent the infection of the lung by bacteria, (2) to minimize the circulation of emboli and their implantation in the lung, (3) to prevent atelectasis, and (4) to minimize shock or other factors whose depressing effect lowers the resistance of the patient.

Inflammation of the upper respiratory tract undoubtedly is a predisposing factor and no operation, save that of emergency, should be done in the presence of infection in the pharynx or nasal

passages. Operation should be postponed for at least 2 weeks where there are symptoms or a recent history of coryza, tonsillitis, or bronchitis. If emergency operations are performed under such unfavorable conditions, nitrous oxide or cyclopropane is preferable to ether because they are less irritating to the bronchial mucosa.

The dissemination of emboli can in a large measure be prevented by careful operative technique and postoperative care. Defects in technical surgery, such as mass ligation and strangulation of tissue, the use of large ligatures, and resultant infection, predispose to the breaking off of thrombi and their lodgement in the lungs.

While the exact cause of atelectasis has not been determined indisputably, obstruction of a bronchus by a mucous plug plays an important, even if a secondary, rôle in its production. Diminished respiration and diminished ventilation with accumulation of bronchial secretions should be reduced where possible. Long periods of narcosis after operation should be avoided, and deep breathing, coughing, and expectoration of bronchial secretions should be encouraged as soon as possible. The inhalation of 5 to 10 per cent carbon dioxide in oxygen at the end of operation and 2 or 3 times daily in the immediate convalescent period is the best stimulant to deep respiration. Abdominal binders should not be so tight as to inhibit respiration and the patient's position should be frequently changed to prevent hypoventilation. Opiates should be given in sufficient amounts to allay the pain of coughing. During the operation and immediately thereafter Gray advocated the Trendelenburg position in order to favor the gravitation of secretions from the lungs. Should atelectasis develop, the patient should be rolled back and forth on the uninvolved side (4) and encouraged to cough.

Should definite pneumonia develop, whether as a sequel of bronchitis, infarction, or atelectasis, the treatment is no different from that uncomplicated by operation. The use of oxygen, sulfapyradine and other chemical and biological agents should be prescribed as indicated.

Measures should always be taken to avoid exposure of the patient to sudden changes in temperature, particularly to cold and chilling. Shock from the trauma of operation and loss of blood should be minimized where possible and blood loss should be replaced by transfusion. Where circulatory failure from cardiac disability supervenes or is suspected, measures to correct it by digitalization should be carried out. It is emphasized again that pulmonary complications are the all too frequent sequelæ of operations, but proper preparation of patients and careful attention to the technical performance of operations will go far in eliminating them.

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RELATIONSHIP OF BRONCHOSCOPY TO SURGERY OF THE RESPIRATORY TRACT

JOHN D. KERNAN, M.D., New York, New York

IN dealing with bronchoscopy in its relation to thoracic surgery, I wish to advance the thesis that the 2 are as closely related as are, for instance, cystoscopy and genito-urinary surgery. The bronchoscope, of course, cannot take the place of surgery. It must be regarded merely as an instrument for more precise diagnosis and at times an aid in treatment.

If one bears in mind that the symptoms of most of the pulmonary diseases are much the same as are also the physical signs and roentgenographic appearances, it will be seen that differential diagnosis is urgent and the importance of a direct inspection of the tracheobronchial tree will be understood at once.

No discussion of thoracic disease is complete without consideration of foreign bodies in the food or air passages. As is known, foreign bodies in the tracheobronchial tree or esophagus, especially in their secondary effects, may produce the symptoms of any known pulmonary disease. They are especially to be remembered in connection with lung abscess. Since history, physical examination, and roentgenograms may all be negative in lung suppuration as to the presence of a foreign body, although such an object is present, a bronchoscopy is always indicated. In a large majority of instances the correct diagnosis will be made and removal will then follow. This will probably cure the patient. If it does not, the proper surgical procedure can then be adopted. Drainage of a lung abscess will never be successful as long as the foreign body remains.

Another use of the bronchoscope in connection with lung suppuration is localization. In roentgenograms the shadows of the lobes overlap one another. I am quite aware that oblique and transverse films have greatly improved roentgenographic diagnosis since the days when only anteroposterior films were taken. Still in connection with small suppurations, even the best of films are at times uncertain. Then the tracing of the pus to its point of origin may exactly localize the trouble. Need I point out how such localization simplifies the task of the surgeon?

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Localization may be aided further by the injection of lipiodol through the bronchoscope. Ordinarily lipiodol is placed by successfully dropping it through the larynx with the syringe. If it is desirable, however, to get just the right amount in the right place, no method is more successful than the use of the bronchoscope.

Another assistance which the bronchoscopist may render is that of preliminary drainage. Many abscesses of the lung recover spontaneously with medical treatment and postural drainage. A certain number again, unimproved by these measures, will recover as soon as regular bronchoscopic treatments are instituted. There are, however, many patients with lung abscesses who will need external surgical drainage for their cure, no matter how faithfully the medical treatment and bronchoscopic drainage are carried out.

The internal drainage in these patients may be so poor that the individual is septic, racked by pain, and in such depressed condition as to be a poor surgical risk. At such times then, bronchoscopic drainage, repeated a few times, will relieve the septic condition and so improve the general condition of the patient as to make successful surgery possible. This is so particularly in the acute stage of lung abscesses. As is known, there is always necessity for surgical delay in the acute stage of lung abscess. Every patient should be bronchoscoped at once when the diagnosis is made. There are 2 purposes in this: first, to rule out a foreign body or other aspirated material, and second, to establish immediate drainage. The ruling out of a possible foreign body and its immediate removal, if found, need not be enlarged upon.

The beneficial effects of prompt aspiration early in the evolution of a lung abscess is not so well understood. Following such operations as a tonsillectomy or other operations about the mouth, it has been noted by many authors that prompt recovery from the abscess often follows even 1 bronchoscopy. The explanation may be as follows: Such abscesses are most frequently due to aspiration of foreign material, either blood, vomitus, or bits of tonsils. I myself have removed a bit of tonsil, microscopically proved, from the lung of a patient with lung abscess following tonsillectomy. Many other such cases must occur.

It is, moreover, a matter of observation that a large percentage of posttonsillectomy abscesses recover promptly after 1 bronchoscopy. I should urge something even more radical. Any patient in whom the surgery has been about the mouth or in whom vomiting has occurred during operation should have a bronchoscopic drainage before being removed from the operating table.

How may the bronchoscopist be useful in connection with bronchiectasis? There is no doubt that many if not most cases of bronchiectasis are postpneumonic, due to retention of secretion in the bronchi which the patient is too weak to expel. Aspiration of this will prevent development of bronchiectasis. In developed cases of bronchiectasis the bronchoscopist may aid in 2 ways. Localization and estimation of the extent of the bronchiectasis are most important. It frequently happens that because of the presence of unexpelled pus, lipiodol introduced in the ordinary way will not enter the diseased areas. This difficulty may be overcome by first aspirating the pus through the bronchoscope and then introducing the lipiodol, preferably under the fluoroscope. This method will reveal the exact extent and site of the disease so the surgeon may know what and how much lung must be removed.

Another thing must be considered. Frequently the pus of bronchiectatic cavities is most infectious. In such cases preliminary bronchoscopic drainage will render operation much safer by reducing the infectiousness of the pus. When an abscess quite full of pus is opened and there is compression of the lung, the pus will be expressed into the rest of the tracheobronchial tree. This may result in immediate danger of suffocation by drowning. If a bronchoscopist is present, this pus may be aspirated at once and the danger prevented. Moreover, pus spread in such a manner may cause postoperative infection in other parts of the lung, but immediate aspiration will set aside this danger of further infection.

The next specific lesion of the lung in which the bronchoscope may be useful to the thoracic surgeon is a benign tumor. Any benign tumor, whatever its nature, will block the bronchus in which it is growing as soon as it is large enough. The result of this will be collapse of the tributary lobe and, if infection occurs, abscess or bronchiectasis. In the presence of such a case the surgeon will wish to know the cause of the obstruction at once, whether foreign body, stricture, or tumor, and the possibility of overcoming it without surgery.

If a tumor is found, a biopsy must be taken to settle the question of malignancy. We will suppose a benign tumor is found. Then the bronchoscopist must be prepared to advise as to the possibility of its removal bronchoscopically, and in this way the drainage or cure of the suppuration or the necessity of a lobectomy can be decided upon. The following is a case in my own experience:

A young man had had pulmonary hemorrhages for 3 years. By means of a biopsy these had been shown to be due to a benign adenoma of the left lower lobe bronchus. This growth was of such a size that it blocked the bronchus, and as infection had occurred, the patient had an extensive bronchiectasis of the left lower lobe. This was considered so severe and extensive that a lobectomy had to be considered. Two questions were raised. Could the growth be destroyed endoscopically? This was answered in the negative and external operation was decided upon. Then the question arose, should a lobectomy or a total pneumonectomy be undertaken? Careful examination disclosed that the neoplasm involved the upper lobe bronchus as well as the lower. This proved the necessity of a pneumonectomy. By means of the use of sulfanilamide and repeated bronchoscopic aspirations the infection was overcome to such an extent that the operation was successfully carried out.

A number of questions arise in connection with malignant tumors. Unfortunately, in these cases the diagnosis is usually made so late that the patient is beyond surgical help. It is only by the use of the bronchoscope that early diagnosis can be made. As a rule, a malignant tumor is suspected. It then remains for the endoscopist to demonstrate the location and extent of the tumor, and by taking a biopsy, its nature and degree of malignancy are determined. In patients in whom the growth involves the main bronchi and is intrabronchial the procedure is simple. But if the growth has arisen in the distant parenchyma of the lung, the matter is much more difficult.

In such patients the bronchi as far as can be seen are normal in appearance and mobility. If, however, any secretion, even though scant, can be secured from the suspected area, it may be possible to demonstrate cancer cells. Thus an early lobectomy would be possible. I quote a case to illustrate the bronchoscopic possibilities of early diagnosis of lung cancer:

In a man suspected of having a malignant tumor of the right lung, a small biopsy was removed from the region of the middle lobe opening. This was pronounced carcinoma. A little doubtful, the surgeon called for a second biopsy. This also was positive. The lung was then removed and no intrabronchial tumor was found, but a large carcinomatous gland was located in the hilum of the lung. Imagine an intrabronchial carcinoma so early that it could be removed endoscopically!

The question most often asked the endoscopist is whether or not, enough uninvolved bronchus remains to form a suitable stump when a lobectomy or pneumonectomy has been decided upon.

As a rule, this question can be answered. For example, the neoplasm may be below the mouth of the upper lobe bronchus. Then if the carina is not distorted and the proximal tube is flexible, one may conclude that the upper part of the bronchus and the hilar glands are not involved. Under such conditions a suitable stump may be secured. An endoscopy certainly should always be done before a lobectomy is started. For example, the film of a man of 60, who was thought to have a malignant tumor in the left upper lobe, suggested that this would be a good case for lobectomy judged from the peripheral position. The bronchoscopy, however, showed a large mass in the main bronchus. Here a total pneumonectomy was called for.

Another field for the collaboration of endoscopist and thoracic surgeon is tuberculosis. Even so simple a procedure as a pneumothorax frequently calls for a previous bronchoscopy. At times the collapse of the seemingly diseased lung is followed by the disappointment of a continued positive sputum. A bronchoscopy may show extensive bronchial disease on the other side. It may be said, too, that the bronchoscopist is prepared to correct, to a great extent, tuberculous lesions of the bronchi which may render operation unsafe.

Endoscopic inspection reveals an astonishing number of ulcers, tumors, and strictures in tuberculous patients. Surely a thoracic surgeon before an extensive thoracoplasty, for example, should know the condition of the trachea and bronchi. Let us suppose that an operation is planned for the closure of cavities full of pus. It should be known that the bronchi leading from such cavities are open and that they will give free drainage after the operation.

The bronchoscopist is prepared to offer something after as well as before operation. All surgeons no doubt have had bad moments when a weakened patient, unable to clear his lungs, seemed almost drowning in his own secretions. At such times a bronchoscopic aspiration will be life saving. It seems to me that every service for thoracic surgery should be prepared to perform postoperative aspiration when necessary.

One more thing I might mention. A double bronchoscope has been devised through which it is possible to separate the air from the 2 lungs. This makes it possible, for instance, to estimate the capacity of the one lung to carry on when it is proposed to remove the other. I know this has been presented to the Society for Thoracic Surgery, yet it never seems to have aroused interest.

It will be seen then from these remarks that the bronchoscope offers the thoracic surgeon possibilities of accurate localization of intrapulmonary disease, the taking of biopsies, the placing of lipiodol, and general and local drainage, either before or after operation; and I have tried to point out the specific application of the bronchoscope to the various pulmonary diseases.

PRINCIPLES IN THE TREATMENT OF EMPYEMA

WILLARD VAN HAZEL, M.D., F.A.C.S., Chicago, Illinois

THE fundamental principles in the treatment of acute empyema of the pleural space are often eclipsed by details of minor importance. Articles appearing on this subject are misleading when they attribute good results to a single point and fail to emphasize the adherence to principles. Details in securing a favorable outcome cannot be overlooked but their importance must be secondary to fundamentals. An important principle is to avoid open pneumothorax early in the course of the disease. To ignore it increases mortality. There is much experimental and clinical proof that increased pressure in one pleural cavity is reflected in the pressure of that on the opposite side. Graham and Bell working on the empyema commission during the World War stressed this point and showed that the mediastinum cannot be regarded as a fixed partition. Whatever occurs to change this pressure, such as disease from within or operative procedures on the chest wall allowing an open pneumothorax to develop, may cause embarrassment to the respiration and circulation through its increased pressure in the side operated upon as well as a transmitted increased pressure to the sound side.

Empyema is a complication and not a disease. Because it is a complication, the primary disease must be taken into account. The streptococcus, the pneumococcus, and the anaerobes are the common organisms encountered. One may become suspicious of the development of an empyema when the fever subsides and then rises again. This is more often true in the pneumococcic type, which forms more slowly and gives evidence of its presence when the symptoms and signs of the process within the lung are subsiding. In the streptococcic form the process forms simultaneously with the pneumonic process and the accumulation is very rapid in some instances. In children the pneumococcic type may occur along with the primary disease and simulates the streptococcic form. The pus aspirated early in a streptococcic empyema is thin, sometimes turbid or serosanguineous, and contains little fibrin. This pus becomes thicker rather slowly; in some instances it takes a period of a couple of weeks. This is in contrast to the pneumococcic form in which the pus is usually thick, fibrinous, and abundant at the time the diagnosis is made. The latter, therefore, exists more in the nature of a walled off abscess, whereas the former may involve the entire pleural surface early in its course. The marked absorptive surface of the pleura in these cases is one factor in the toxemia sometimes observed. These facts have their application in the choice of procedure in a given case.

From the Department of Surgery of the University of Illinois College of Medicine.

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There are 2 objectives in the treatment of an empyema. The first is to establish adequate drainage, the second is to obliterate the cavity. No case can be assured of a good end-result without their fulfillment.

However, before the establishment of drainage it is well to consider the individual factors in the case. The immediate need may call for relief from a constant cough due to pressure which with delay might rupture into a bronchus. Embarrassment both to respiration and circulation from large accumulations of pus may occur, or the overwhelming signs of sepsis in highly virulent infections may be present. This relief may usually be accomplished to a degree by aspiration of some of the pus. The magnitude of an operation in any field often governs the risk involved. By the same token, the least possible procedure may be sufficient to improve the condition of the patient in order to make subsequent procedures safer. It is with this in view that aspiration of purulent material serves its greatest usefulness. A lower temperature and decreased respiratory and pulse rate usually follow. In some instances of mild virulence or small pockets it may be sufficient to cause symptoms and signs to disappear.

Adequate drainage, however, is usually accomplished by either the closed or open method. The difference in the 2 methods lies in the fact that the closed method attempts to avoid an open pneumothorax with its danger of increased intrapleural pressure. In a well walled off abscess this danger does not exist. We presume the presence of adhesions when the pus is thick, but this presumption allows for an error in judgment. Therefore, it does seem that preference for the closed method of drainage adds a margin of safety. Whenever the pus is thin and sepsis makes adequate drainage desirable, the closed method is

imperative. It is in this type in which the parietal and visceral pleuræ have not yet become adherent, that the mediastinum may be mobile and the collapse of the lung may result if a portion of a rib is resected and an open pneumothorax develops. It is also likely in this type that the pneumonia may still exist and the toxemia attendant upon it does not safely permit the added burden created by an open pneumothorax too early in the disease. It is here then that the primary disease must be reckoned with in the choice of procedure. The ease with which a tube is inserted under local anesthesia without moving the patient is a worthwhile consideration when the patient shows the effects of prolonged or virulent infection. Closed drainage is not an attempt to avoid a rib resection, although that, too, may be accomplished. It is merely a method to provide adequate drainage without an open pneumothorax in any case but particularly in those in which pneumothorax increases the risk of morbidity and mortality.

Open drainage accomplished by the resection of a segment of one or more ribs is likewise adequate. When done at the proper time it gives equally good results. Any number of series of cases are reported by as many authors whose results compare favorably no matter what method is used. However, these enviable results include the recognition of fundamentals.

Once adequate drainage is obtained it is of equal importance that it be maintained lest the signs of sepsis reappear. In closed or open drainage this is best accomplished by the introduction of solutions, such as normal saline or chlorine preparations, into the pleural cavity, and provision should then be made for their removal. Tidal irrigations and many other means have been suggested to accomplish this. Their value cannot be overlooked. The washing and removal of necrotic material and fibrin, which otherwise might organize and encapsulate organisms, will undoubtedly decrease recurrences. The sterilization of the cavity is demonstrated by cultures made from the washings.

The second chief objective is the obliteration of the cavity. The mechanism by which this is accomplished is an obliterative pleuritis. This process is sometimes observed in patients undergoing artificial pneumothorax treatment for pulmonary tuberculosis. A pleurisy develops followed by the formation of fluid. Adhesions between the parietal and visceral pleuræ may then take place and this becomes a creeping process in which the lung gradually re-expands and nullifies the effectiveness of the treatment. So, too, in the inflammatory process of an empyema, once the adhesions are established the contraction of these adhesions gradually progresses. Besides this there is the inherent tendency of the lung to expand, a displaced mediastinum to return to its normal position, and a depressed diaphragm to elevate. Factors which play a part in hastening this objective are adequate drainage, solvent action of irrigations on a thickened visceral pleura, maintenance of a degree of negative tension in the pleural cavity, and increase of intrabronchial pressure. Not all cases re-expand with the same rapidity nor are all aided by the same measures or any measures devised for hastening this re-expansion. The size of the pocket, the type of infection, the time of drainage, the condition of the patient, and the presence of a bronchial fistula influence re-expansion of the lung.

The obliteration of the pleural space is a gradual process and in closed drainage is demonstrated when fluid will no longer enter the cavity provided that the reduction in size has been progressive. It also is more conclusively visualized by filling the cavity with an opaque solution from time to time and by obtaining roentgenographic evidence as to the size and shape. In open drainage the cavity properly cared for can be visualized directly and its progress observed.

Interlobar, mediastinal, or diaphragmatic collections of pus are best treated as abscesses. As such, open drainage is indicated in order to determine the presence of adhesions and thus enter the abscess without its dissemination to a clean, pleural space. Soiling of the pleural cavity in instances in which the infection is virulent or caused by anerobes is very serious.

The importance of dependent drainage has been overemphasized. It has led to injuries of the diaphragm and peritonitis. The eighth or ninth interspace in the posterior axillary line in the common posterolateral empyema is sufficiently low. In adequately drained empyemas, which are opened for the obliteration of a residual cavity, the cavity lies almost invariably above the sinus thus indicating that drainage at this point has accomplished its purpose.

The treatment of tuberculous empyema is a subject in itself. Any patient with pus in the pleural cavity and a history of insidious onset should be suspected of having sterile pus. The treatment here is not drainage and the difficulties encountered in caring for those in whom it occurs warrant the routine procedure of smear and culture prior to instituting drainage. The smear does not always reveal organisms even in pyogenic cases but the culture media will. It is always

necessary, however, to use anerobic as well as aerobic culture media in order not to obtain a report of no growth.

Hedblom once wrote: "The course and outcome of an empyema is determined not only by treatment but also by type and virulence of infection, pathologic anatomy, age and general condition of the patient, and the nature and gravity of the primary infection of which it is almost always a complication."

I have purposely refrained from suggesting various means of accomplishing some of the objectives which to me seem important, but have endeavored rather to adhere to the underlying fundamental principles which should guide us in our method of procedure in the treatment of this disease.

In spite of our best efforts there are some patients who will succumb. This occurs when empyema is only one of the complications which attend a generalized infection, such as pericarditis, peritonitis, or meningitis. Nevertheless, as we individualize the treatment of empyema and adhere to accepted principles, we will lower the mortality, lessen recurrence, and reduce chronicity.

OBSTETRICS AND GYNECOLOGY

PROPHYLAXIS AND TREATMENT OF CARCINOMA OF THE CERVIX AND BODY OF THE UTERUS

WILLARD R. COOKE, M.D., F.A.C.S., Galveston, Texas

IT is impossible, because of space limitations, to do more than just touch upon some of the essential features of so broad a subject as carcinoma of the cervix and endometrium; moreover there have been no spectacular advances in our general knowledge of cancer during the past year. The fact remains, however, that a great deal of cancer of the cervix can be prevented and a great many cases of established cancer can be cured through the application of our presently imperfect methods of prophylaxis and treatment.

CANCER OF THE CERVIX

Prophylaxis. In spite of all that has been written and said concerning the prophylaxis and early diagnosis of cancer of the cervix, the status of most of the patients referred for treatment is as bad as it was many years ago. Formerly, or roughly speaking before 1925, most of our patients were first seen in a hopelessly advanced stage because of the Victorian prudery of that period. In simple words, it was the fault of the patient. Today, however, thanks to the publicity given the subject, most women are informed of the suggestive symptoms of cancer of the cervix and ask for examination promptly upon the appearance of such symptoms; and an ever increasing number report for a semi-annual examination in the absence of symptoms. In spite of this, the incredible apathy of the profession at large toward prophylaxis and the quite simple technique of the recognition of early cancer of the cervix have resulted in a general failure to accord the patient the adequate examination which she deserves. In other words, it is now the fault of the profession at large that the incidence and mortality rates of cancer of the cervix show little improvement.

There are only 2 symptoms suggestive of early cancer of the cervix or corpus uteri: the appearance of discharge or of bleeding independent of menstruation. Either of these should promptly cause the patient to seek competent examination. From the doctor's point of view the most important factor in the problem of cancer of the cervix is that there are 2 very common and easily recognized benign lesions which are definite forerunners of most cases of cancer of the visible portion of the cervix. These are heteroplasia and leucoplacia. Heteroplasia consists of the replacement of normal squamous epithelium by an outgrowth of cylindric-cell epithelium of the type normally present only within the cervical canal. There are 2 types: the spontaneous variety, generally called erosion or ectropion—a more correctly descriptive name for the condition is "ectrophion," since the process is one of outgrowth rather than excoriation or out-turning—and the variety known as eversion, which is caused by the healing-over of the raw surfaces of a laceration by cylindric-cell epithelium instead of the more resistant and appropriate squamous type. Leucoplacia, roughly speaking, consists of a localized keratoid change in the mucosa with diminution of the cellular glycogen content, which is recognized by its comparative pallor and by its failure to show staining upon the application of iodine. Fortunately, the vast majority of heteroplasias and leucoplacias fail to eventuate in malignancy; yet most cancers of the visible areas of the cervix have their origin at the edge of a heteroplasia or in a leucoplacic lesion.

A thoroughly competent gynecologist is able usually to determine by gross inspection whether he is dealing with a benign heteroplasia or with an early cancer; but if there is any doubt, or if the lesion bleeds upon gentle trauma, the competent gynecologist immediately resorts to biopsy for a definite microscopic diagnosis. This very simple procedure is harmless to the patient and is available to every practitioner who possesses a speculum and a knife. Biopsy is best done with a sharp punch forceps capable of removing about a cubic centimeter of tissue and should be followed by actual cauterization of the raw surfaces to control bleeding and to seal the opened tissue

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spaces. However, biopsy may be done safely with a minimum of equipment. The whole procedure including cauterization is infinitely less painful than the filling of a dental cavity and requires no anesthetic. If the lesion under investigation is benign, simple destruction of the abnormal tissue with the cautery, which is best done at a single sitting rather than as a series of partial cauterizations, practically always results in a permanent cure and requires no anesthesia except in the case of very extensive eversion or ectropion in sensitive individuals. The efficiency of the adequate treatment of heteroplasia as a prophylaxis against cancer is indicated by the report of 1 clinic in which only 1 case of cancer developed in over 2,000 adequately treated cases of heteroplasia; whereas 19 cases of cancer occurred in 187 cases of untreated, advanced heteroplasia. From the patient's point of view the universal application of the principle of biopsy in all doubtful cases would result in a great deal of unnecessary discomfort and expense, since it is not possible for everyone to be a thoroughly competent gynecologist; yet these are trivial considerations when one takes into account the number of advanced cancers, the unnecessary radical operations, and radiations which would be prevented by universal application of this course of procedure.

The recognition of cancer of the cervical canal above the visible portion is a more difficult problem and depends upon the methods to be described under carcinoma of the endometrium. It is usually possible to determine whether the hemorrhage is coming from the cervical canal by plugging the internal os with a cotton-wrapped stick and watching for continued bleeding.

Treatment. In the case of cancer of the cervix it is almost universally conceded that combined radium and roentgenotherapy is at present the method of choice for 2 reasons even in cases in the operable clinical stages: (1) because flat cell cancer is usually radiolabile, and (2) while a few operators have become so adept in radical hysterectomy as to obtain a percentage of cures equal to that of radiation, such a degree of skill can be acquired only through a long period of education during which the postoperative mortality rates are prohibitive. Certainly the occasional pelvic operator should never attempt a radical hysterectomy for cancer of the cervix. In the case of cylindrical cell carcinoma with its theoretically high degree of radioresistance, radical hysterectomy may prove to be the method of choice, if at all possible. If it were feasible to determine in advance whether a given cancer is radiolabile or not, the choice of procedure would be easy. Unfortunately, radiosensitivity is not accurately indicated by any histological feature, and the failure of test radiation induces changes in the normal tissues which render operation much more difficult and dangerous.

If hysterectomy is attempted too soon after radiation, hemorrhage from dilated minor vessels is apt to prove troublesome or even insuperable; and the impairment of the defense mechanism and of the processes of repair often result in infection and failure in healing. If hysterectomy is delayed too long after radiation, the condensation of the areolar tissue and the obliteration of planes of cleavage make the recognition and isolation of the ureters, bladder, and other important structures very difficult or even impossible.

In the employment of radiation, it is now certain that the combination of radium and adequate roentgenotherapy increases the percentage of cures. There is no generally accepted technique in the use of radium, except as regards proper screening and the essential factor of the single massive dose amounting to 3,600 to 4,800 or more milligram hours. The effectiveness of roentgenotherapy increases with the voltage of the generator and with the proper choice of multiple fields of exposure. Treatment through a single portal with machines of low voltage adds little or nothing to the effectiveness of treatment with radium alone. Roentgenotherapy of cancer of the cervix definitely requires close co-operation between the gynecologist and a radiologist thoroughly trained in the principles governing this particular field.

CARCINOMA OF ENDOMETRIUM

Prophylaxis. Since there are no known forerunning lesions of cancer of the endometrium, the prophylaxis is limited to the application of the principle of immediate biopsy upon the appearance of persistent intermenstrual bleeding, especially in women past the age of 35. As in the case of biopsy of the cervix, the vast majority of cases will prove to be non-malignant. Estrus syndrome, hyperplasia, atrophic endometritis, mucous polyp, submucous or intramural fibromyoma will usually be found yet the adoption of this principle is justified. Biopsy of the endometrium can be done only through curettage; and there are 2 points concerning diagnostic curettage which must be borne in mind: (1) The curettage should remove every possible scrap of endometrium, every scrap should be saved, and every scrap should be examined microscopically. The collection of the scrapings placed immediately into a basin of water aids the pathologist tremendously through the elimination of masses of clotted blood. (2) In the event

of a negative biopsy report in a case which is clinically one of carcinoma of the endometrium, the patient should be treated for carcinoma. Of course, in most such instances the diagnostic curettage may be omitted.

Diagnostic curettage should be done in every case of premenopausal metrorrhagia. Not infrequently, early carcinoma is discovered in the scrapings from a case which is clinically and grossly non-malignant. The possibility of the existence of granulosa-cell tumor of the ovary should be taken into account in every case which is clinically one of carcinoma of the endometrium with a histological report of hyperplasia only, since in some cases there is no palpable enlargement of the ovary.

Treatment. The present consensus in cases of carcinoma of the endometrium remains unchanged, i.e., that complete hysterosalpingo-oophorectomy offers the best ultimate percentage of permanent cure and is usually adequate. It is possible that the accumulation of data will indicate that routine postoperative roentgenotherapy may increase the percentage of cures. It is also possible that relatively new methods of combined radium and roentgenotherapy may supplant the operative attack. Since carcinoma of the endometrium usually has a very slow rate of invasion, it is unnecessary in the vast majority of cases to carry out the radical extirpation of the pelvic cellular and lymphatic areas which is required in cases of cancer of the cervix; hence the postoperative mortality rate is quite low. It is, however, important that the cervix and ovaries should be removed in every case, since it is into these structures that extension and invasion are first apt to occur. Routine microscopic study of the material which has been removed, especially the extra-uterine tissues, should be carried out; and if carcinomatous invasion beyond the myometrium has occurred, the patient should certainly receive intensive roentgenotherapy. Of course, in inoperable cases or those in which extra-uterine invasion is palpable, radiation is the only possible method of treatment.

CONCLUSION

While there has been a definite reduction in the incidence and mortality of cancer of the uterus, especially of the cervix, managed throughout by thoroughly competent gynecologists, the general mortality rate from these conditions shows little or no improvement. At present this is due to the failure of the profession at large to recognize and treat the conditions predisposing to cancer of the visible areas of the cervix, and to resort to biopsy in all doubtful cases. The greatest hope for reduction of the rates of incidence and mortality of cancer of the uterus lies in the routine examination every 6 months and promptly upon the appearance of any abnormal bleeding or discharge between these periodic examinations of all women over 30 years of age, in the recognition and treatment of heteroplasia and leucoplacia, and in the employment of biopsy in all cases of doubtful diagnosis.

In the treatment of actual cancer of the cervix, combined radium and roentgenotherapy is the method of choice. Adequate roentgenotherapy requires (1) complete co-operation between the gynecologist and radiologist, (2) special high voltage equipment, and (3) a technique employing the principle of proper exposures through multiple portals.

Complete hysterosalpingo-oophorectomy remains the generally accepted method of choice in the treatment of carcinoma of the endometrium. Since this condition does not require the very difficult and dangerous extirpation of the pelvic lymphatic areas, the mortality rate is low. It is possible that in the future the development of new principles in the application of radiation to this condition may result in its adoption as the method of choice.

ENDOCRINE THERAPY IN OBSTETRICS AND GYNECOLOGY

JOHN C. BURCH, M.D., F.A.C.S., Nashville, Tennessee

THE most common endocrine conditions requiring treatment in obstetrics and gynecology are those affecting the process of menstruation. The treatment of these conditions will be discussed in detail, as the underlying principles will be found applicable to other conditions of endocrine origin affecting the female genital tract.

For the rational treatment of any condition an accurate diagnosis is an essential prerequisite, and so it is in the field of menstrual disorders. In a number of previous publications (2, 4, 5) the work of our group has been reviewed, and a detailed exposition of the experimental evidence on which our concept of menstrual disorders is based can be found in these articles (Figs. 1 to 4). This general working concept may be stated as follows: Functional menstrual disturbances can result from a lesion in any of the endocrine glands or from some general constitutional condition secondarily affecting the endocrine system. The endometrium indicates roughly the degree of ovarian involvement. There is no constant correlation between the gland affected, the endometrium, or the type of menstrual disturbance.

From this it follows that a primarily diseased ovary may produce endometrial changes and a type of menstrual disturbance identical with those produced by a lesion in some other gland such as the thyroid or pituitary. A menstrual disturbance, therefore, is not a disease, but a symptom, referable to a variety of conditions. To treat all amenorrheas alike is no more rational than to treat all fevers alike. On the other hand, under certain circumstances similar treatment may be applicable to such different symptoms as menorrhagia, amenorrhea, sterility, or threatened abortion.

The general principles underlying the treatment of menstrual disorders have been discussed previously (3, 5). They are: (1) an accurate diagnosis, (2) the rational use of endocrine preparations, (3) elimination of contributory disease, and (4) evaluation of rôle of radiation and surgery.

In diagnosing a menstrual disorder, the first essential is to distinguish between the organic and the functional. In many cases this is easy enough, but in others difficulty is encountered and mistakes are common. Small submucous fibroids are frequently treated for a considerable period by endocrine means. Subserous and intramural fibroids are frequently removed on account of bleeding, only to reveal an abnormal endometrial picture clearly indicating an associated endocrine lesion. The endometrial biopsy and the uterogram will clear up many of these different problems. Carcinoma is, of course, an ever present possibility.

After having determined that the lesion is functional, we must determine the gland primarily affected, as well as any other contributory disease. This calls for a general examination and history, as well as a few simple physical measurements, a basal metabolism, sugar tolerance, and blood chemistry studies. Goldzieher's specific dynamic action test (14), while recently criticized (30), may have considerable value. The evaluation of the data obtained will generally lead to a diagnosis. Hormone assays of the blood and urine are useful in the diagnosis of pregnancy, chorio-epithelioma, and hydatidiform mole. With this exception, hormone assays are valuable chiefly to the research worker and his findings must be carefully and critically analyzed on account of the difficulties inherent in the technique. These methods are not clinical methods and studies of this type can be omitted in clinical work until the methods are further perfected.

In passing it may be said that much of the confusion surrounding endocrinology is due to the fact that research has neglected diagnosis and featured the interglandular relationships. From a practical standpoint, much of this knowledge is useless to the clinician who cannot make a diagnosis.

Endocrine products used in obstetrics and gynecology are the gonadotropes, the sex sterols, and thyroid.

GONADOTROPES

The gonadotropes are of 3 kinds: (1) pituitary, (2) chorionic, and (3) equine. The pituitary gonadotropes are derived from the gland itself and consist of 2 fractions: a follicle-stimulating and a luteinizing fraction. Due to the expense of preparing the extracts in sufficient concentrations relatively free from other factors, these extracts

From the Department of Obstetrics and Gynecology, Vanderbilt University School of Medicine.

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have not as yet achieved their theoretical rôle. At the moment, from a practical standpoint, they have a limited value.

The chorionic gonadotropes are derived either from pregnancy urine or human placenta; many reliably standardized and excellent preparations are available. In laboratory animals they produce ovulation and corpus luteum formation just as do the pituitary gonadotropes. They differ from these in that they produce only theca luteinization in the hypophysectomized animal. For this reason they are sometimes referred to as the anterior-pituitary-like hormone (A. P. L.). Following the brilliant reports of Campbell and Collip and Novak and Hurd, these extracts have been used with varying degrees of success by many investigators. Some continue to claim exceptional results, while others, notably Hamblen (16), doubt the therapeutic worth of these preparations. In a recent article (16) he has reviewed the evidence and it seems definitely proved that they do not produce ovulation or structural changes in the human ovary or endometrium. Under no circumstances can they be expected to cause ovulation in a non-ovulating woman. In normal women the production of supernumerary corpora has been reported (6, 26, 40). The excretion of an increased amount of pregnandiol follows their use (1). In my own practice I have found them useful under certain conditions. Their most reliable action is a gonad-maturing one, which is best seen in male cryptorchidism. Their use is indicated in young girls with primary ovarian failure, and in these cases they are of great value. In elderly women with primary ovarian failure, they are of less value and may be entirely worthless. They are also useful in secondary ovarian failure for their stimulative action during the time when one is waiting for more specific measures to take effect. On the whole, too much has been claimed for these preparations, but when used according to their indications they are extremely useful. As regards dosage, a conservative dose is 500 rat units per day while the patient is bleeding and 250 rat units twice a week during the non-bleeding phase.

Equine gonadotropes are derived from the serum of the pregnant mare. They have been used for some time but, due to patent and licensing difficulties, they have become commercially available in this country only recently. These hormones have been reported by Davis and Koff to produce ovulation in the non-ovulating woman when given intravenously. Hamblen (16) and his group have not been able to secure ovulation by giving them subcutaneously. These preparations are undoubtedly potent and have much to recommend them. On account of their equine origin the dangers of a reaction must be considered. As sufficient data accumulate, they will undoubtedly find a prominent place in the treatment of various ovarian conditions. Some investigators advocate the use of a combination of the equine and chorionic preparations (22, 24). Rydberg and Östergaard recently reported considerable success in the treatment of amenorrhea by the administration of 2,000 mouse units of an equine gonadotropic preparation (Antex-Leo) daily for 5 days followed by 5 injections of 2,000 mouse units each of anterior-pituitary-like hormone every other day.

SEX STEROLS

Under this term are included a number of different preparations, such as the estrogens, male hormone preparations, and progesterone. The estrogens are undoubtedly the most important of the group and are used by practically all practitioners. The indications for their use are rather well defined and failure to observe these indications has led to much indiscriminate treatment. Their action is three-fold: They have (1) a stimulative effect upon the luteinizing hormone of the pituitary (11), (2) a sedative effect upon the nervous system (38), and (3) a trophic effect upon the lower genital tract (33). They are, therefore, indicated in the treatment of pituitary failure both on account of the fact that they stimulate the pituitary and because they make up for the secondary deficiency in estrogen. In pituitary failure it is usually advisable to use them in combination with thyroid on account of the action of this hormone upon the pituitary, and also because of the secondary thyroid deficiency which often exists in these cases. This combination of estrogenic and thyroid hormones will be found satisfactory for the treatment of many pituitary cases.

Hamblen (17) has recently reported excellent results from the treatment of menometrorrhagia by the cyclical employment of 10,000 international units of estrogen daily for a period of 21 days followed by 5 milligrams of progesterone daily for 5 days. Most of the patients treated have had regular periods and some, after the cessation of treatment, have continued to menstruate regularly. This form of treatment is rational when applied to the pituitary and ovarian groups. If used in thyroid cases, substitutive therapy with thyroid will be required.

On account of their stimulative effect on the lower genital tract the estrogenic hormones have found a wide field of usefulness in the treatment of vulvovaginitis of infancy (19, 21, 39) and

atrophic disturbances of the menopause (18, 28, 41). They are indicated in the treatment of ovarian failure at or near the menopause or following operation. On account of their sedative effect upon the nervous system, they have been used extensively in menopausal conditions, although the observations of Pratt and Thomas perhaps indicate that their effect has been overestimated. In spite of this I have continued to use these hormones for the treatment of menopausal symptoms and with satisfactory results.

In the pituitary cases, dosages of the estrogens range from 1,000 to 10,000 international units per day (in the case of the tablets for oral administration) or from 1 to 3 teaspoonfuls per day of the preparation known as emmenin. For the vulvovaginitis of infancy the dosage should be 1,000 international units each day given in the form of a vaginal suppository. It is impossible to define the amount necessary to control the symptoms in the menopause, as this will vary according to the amount of estrogen produced by the patient's own ovaries. The ordinary range of dosage is from 2,000 to 10,000 international units; this may be repeated daily. In the average case, a weekly dosage of 6,000 to 10,000 international units will be found sufficient, although in some instances larger amounts will be needed.

While the estrogens have undoubtedly been of great benefit and have contributed much to the happiness of many individuals, certain drawbacks exist as regards their use. In the first place, the preparations are expensive and, in the second place, hypodermic administration is often required. This has cut down on their practical value. These disadvantages have led investigators to seek other substances having an estrogenic effect. Dodds in studying compounds with estrogenic activity, was much impressed with the simple substance stilboestrol (derived from stilbene). This substance, while chemically different from the biological estrogens, has all the properties which they possess. In addition, it is relatively non-toxic, readily absorbed when given orally, and will be considerably cheaper when commercially available. I have been fortunate in having had placed at my disposal[1] a generous supply of this material, which I have used in a series of 16 cases. Three of these were patients with severe amenorrhea due to pituitary deficiency in whom a large amount of estrogen had previously failed to produce menstruation. One milligram of stilboestrol each day for 25 days produced a normal menstrual flow. This preparation has great promise. And from my experience with it, I consider it to be the most valuable addition to our therapy in recent years.

[1]This material was generously supplied by E. R. Squibb & Sons, through the courtesy of Dr. J. A. Morrell.

Progesterone. This term has been agreed upon as the term which is to be used to designate the hormone of the corpus luteum. It is now available commercially and has been used in a variety of conditions. In my own experience and that of others, it has proved to be of some value in cases of threatened abortion or functional uterine bleeding. At the present time, progesterone therapy must be regarded as purely substitutive in nature, although there is some evidence that the corpus luteum hormone may influence the gonadotropic activity of the pituitary (25).

Testosterone (propionate). This male hormone has been the subject of intensive investigation regarding its effect on the pituitary and on the female genital tract. It seems fairly well established that short term administration of small doses stimulates the pituitary and that prolonged administration causes a depression of pituitary activity (12, 29). Investigators who have studied its effect in the human female have been impressed by the fact that uterine bleeding can be controlled and checked by the administration of this hormone. In a recent study (42), an attempt was made to analyze the effect of this material on the endometrium and it was shown to have a marked effect on the hyperplastic endometrium, consisting in a suppression of proliferation and a lessening of the swelling and edema. The typical estrin effect on the endometrium (Fig. 5, a) was markedly altered (Fig. 5, c and d) and the histological picture was somewhat similar to that seen when testosterone alone was given (Fig. 5, e). Gaines, Salmon, and Geist have reported that testosterone exerts an inhibitory effect upon the cyclic changes in the human endometrium.

Clinical reports indicate that menstruation can be suppressed entirely by the administration of testosterone and that it will reappear in the course of 2 months' time after treatment is discontinued. The hormone has been used in the treatment of dysmenorrhea (23, 35, 37), mastalgia (9, 23), and menopausal symptoms (9, 20) as well as for the control of abnormal uterine bleeding. If given in excessive amounts it produces a deepening of the voice and a thickening of the facial hirsutes. These usually disappear after the cessation of treatment. Greenhill and Freed recently warned of this occurrence.

THYROID

This is perhaps the most useful of all the hormones in the treatment of obstetrical and gyneco-

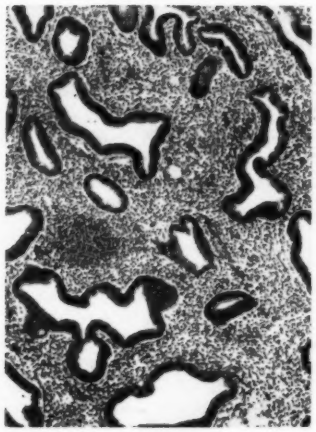

Fig. 1

Fig. 2

Fig. 3

Fig. 1. Human endometrial hyperplasia.

Fig. 2. Photomicrograph of a specimen showing endometrial hyperplasia produced in a guinea pig by long continued treatment with subcornifying doses of estrogen.

Fig. 3. Endometrial hyperplasia produced in guinea pig by extreme partial castration.

Fig. 4. Endometrial hyperplasia produced in guinea pig by partial hypophysectomy.

logical conditions. Its use is indicated in primary hypothyroidism and in hypothyroidism secondary to pituitary disease. In either instance it is given in doses sufficient to raise the metabolism to normal or until it produces untoward symptoms. While thyroid is one of our most common drugs, there seems to be a general lack of familiarity with the technique of its administration and the results which can be obtained. Many physicians regard it as a rank poison. Nothing could be farther from the truth. It is best always to start with a small dose, such as ½ grain each day, and to continue this dosage for a period of 6 weeks, at which time the metabolism is determined and the dosage increased by ¼ to ½ grain. At the end of another 6 weeks the metabolism is again determined and the dosage increased by small amounts only. In case symptoms appear before the metabolism reaches normal, the dosage should be reduced a little for a period of 6 to 8 weeks and then increased again. It is almost impossible to find a patient who will not tolerate thyroid if it is given in this manner. Two points should be especially stressed. In the first place, there is very frequently a paradoxical fall in the basal metabolism in spite of marked clinical improvement. Youmans and Riven consider this a sign confirming the diagnosis and indicating good results. In the second place, in the majority of cases of true primary hypothyroidism, the drug, once started, must be continued indefinitely. It is a common experience for patients of this kind, who have been doing well, to have therapy stopped by some other physician on the grounds that they are well. These patients return to their former disagreeable status and treatment has to be carried out all over again.

Surgery and radiation still occupy a prominent place in the treatment of menstrual disorders. Curettage is by all odds the best way to stop the bleeding in order to allow specific measures to take effect. In addition, the endometrium thus

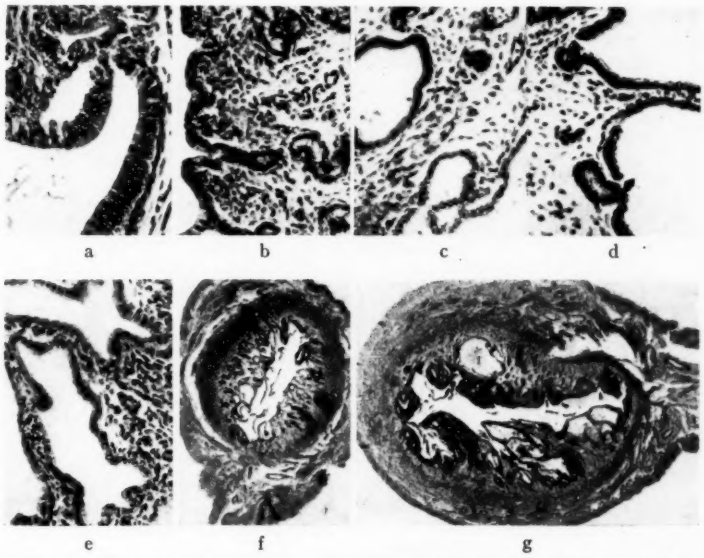

Fig. 5. Effect of testosterone on experimentally produced endometrial hyperplasia in the guinea pig. a, Endometrium of castrate guinea pig which received 6.5 international units of theelin daily for 55 days. b, Endometrium of castrate guinea pig which received 6.5 international units of theelin daily for 40 days; uterus removed 15 days after last injection of theelin. c, Endometrium of castrate guinea pig which received 6.5 international units of theelin daily for 40 days, followed by 6.5 international units of theelin plus 1 milligram of testosterone propionate daily for 15 days. d, Endometrium of castrate guinea pig which received 6.5 international units of theelin daily for 40 days, followed by 1 milligram of testosterone propionate daily for 15 days. e, Endometrium of castrate guinea pig which received 1 milligram of testosterone propionate daily for 34 days. f, Cross section of uterus of castrate guinea pig which received 6.5 international units of theelin daily for 40 days followed by 6.5 international units of theelin plus 1 milligram of testosterone propionate daily for 15 days. g, Cross section of uterus of castrate guinea pig which received 6.5 international units of theelin daily for 55 days.

obtained is valuable in ruling out carcinoma and in determining the degree of ovarian involvement. In certain cases, after consideration of the reproductive function and social and economic factors, as well as the pelvic lesions, hysterectomy associated with endocrine therapy is the most satisfactory means of treatment. I find myself more and more frequently resorting to hysterectomy in those cases in which there are associated pelvic lesions, such as prolapse or cystocele, provided there is no desire for further pregnancies. Vaginal hysterectomy is the procedure of choice under these circumstances.

Radiation can be of 2 types, either stimulative or depressive. Stimulative radiation to the ovaries has produced good results in the hands of Mazer (27) and others, and the dosages recommended apparently can do no harm. The mechanism, however, is somewhat open to dispute and much still remains to be learned concerning this form of treatment. Destructive radiation of the types employed near the menopause, of course, will stop the bleeding and will make the ovarian failure complete. In a certain carefully selected group of cases, this is undoubtedly the method of choice, but it should not be used in the younger age groups or in those cases in which the well known contra-indications exist.

Fibroid tumors are a frequent reason for pelvic surgery. It has been shown recently by Nelson and previously postulated by Witherspoon, that these tumors have an endocrine significance. Not infrequently we remove the tumors and ovaries and stop the bleeding but increase the degree of endocrine imbalance. It is, therefore, well to remember that surgery or destructive radiological

procedure does not cure an endocrinopathy, but merely removes the symptom and may exaggerate the underlying endocrine process. All of these cases should be studied from the endocrine standpoint and patients treated after operation according to the indications.

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THE MANAGEMENT OF PELVIC DYSTOCIA

ALFRED C. BECK, M.D., F.A.C.S., Brooklyn, New York

THE management of pelvic dystocia at the Long Island College Hospital has undergone considerable change during the 27 years of my association with that institution. These changes were effected in 3 fairly distinct periods. The first period, 1912 to 1918, was characterized by the relatively large number of destructive operations that were done on neglected patients. The second, 1918 to 1928, covered the time when we were attempting to determine the value of the low cesarean section. It also was influenced by the work of our prenatal clinic. The third period, 1928 to 1939, began the inauguration of our present routine. Since this routine is the outcome of the lessons learned in the first 2 periods, it may be well to review briefly some of our observations made at those times.

At the beginning of the first period, 1912, our prenatal clinic was started, but in spite of the painstaking work of its personnel a large number of our difficult hospital patients failed to avail themselves of its advantages. The ignorant foreign and negro women in our district usually refused our services until their midwives sent them to us after several days of labor had shown that spontaneous delivery was impossible. Our worst cases of pelvic dystocia, accordingly, were admitted many hours after the onset of labor, long after the membranes had ruptured, and after many vaginal examinations had been made. Almost all of these emergency admissions were potentially infected, and in many evidence of intrapartum sepsis was already present. When the child was dead, as it was in most of these cases, delivery was accomplished by means of some destructive operation. Occasionally, however, the child was alive and in good condition. In such circumstances, the patient's religious objection to feticide and our reluctance to destroy a living child compelled us to resort to cesarean section in spite of definite contra-indications to this operation. While some of these destructive procedures were done with comparative ease, others were extremely difficult. In the difficult cases I soon learned that the uterus might be ruptured easily, that the cervix and vagina might be traumatized extensively, and that many avenues might thus be opened up for the widespread dissemination of any infection that was present. Therefore, if the patient survived the shock and hemorrhage incident to operation, there always remained the chance that she might die from puerperal infection. Even when the operative procedure was an easy one, the patient occasionally died because her condition at the time of admission was too poor to stand any operation.

While the instances in which cesarean sections were done on these neglected patients were not numerous, they were sufficiently frequent to demonstrate the results of suprapubic delivery in such circumstances. Often the patient would recover from the immediate effects of the operation only to die from the abdominal calamity which occurred when the infected uterine wound broke open 5 to 7 days subsequently. Our experience during this first period, accordingly, left us with the following definite impressions: (1) That a destructive operation sometimes requires more skill than is required for the performance of a cesarean section. (2) That a destructive operation cannot always be done in a neglected case of pelvic dystocia without risk to the mother. (3) That cesarean section often can be successfully performed in these cases. (4) That the risk to the mother, however, is too great to warrant the use of cesarean section if she can be delivered by any less dangerous procedure. (5) That the neglected patient's condition may be too poor to stand any operative procedure. (6) That neglected cases of pelvic dystocia are best treated by their prevention through adequate prenatal care.

During the second period, the number of emergency cases was greatly diminished. Due to the growing influence of our prenatal clinic, the majority of our cases of pelvic dystocia then came to us before they went into labor. Antepartum measurement of their pelves was thus possible and the management of their labors was planned before they entered the hospital. The improvement in our management of pelvic dystocia, which should have resulted from this good work of our prenatal clinic, however, was vitiated to some extent by our unfortunate experience with the low cesarean section. The results of this operation in potentially infected cases were so good that we

From the Department of Obstetrics and Gynecology, Long Island College Hospital.

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were misled into believing this procedure to be safer than it really is. A fairly large series of cases was accumulated in which the operation was done late in labor, long after the membranes had ruptured, and after vaginal examinations and manipulations had been made. In these cases, the results were so good that we felt justified in giving all of our borderline cases of contracted pelvis a full test of labor. By this I mean that the labor was allowed to continue until the cervix became fully dilated and the patient had shown by several hours of good second stage pains that the head could or could not pass through the pelvis. If after such a test the head fâiled to enter the pelvis, a low cesarean section was done. After a considerable experience, we learned that our early results were too good to be true and we were compelled to concede that even the low technique did not protect the patient against the hazards which accompany cesarean section performed long after the time for its safe performance has passed. Thus it may be seen that instead of operating upon neglected emergency patients, as we did in the first period, we neglected our own patients and then operated upon them. This mistake in our former routine is frankly acknowledged and it is hoped that others may profit by its publication.

While our pioneer work with the low cesarean section revealed the limitations of the operation, it also demonstrated the value of this technique. Although the operation cannot be done without a 3 to 5 per cent risk after the patient has been in labor 24 hours, or after the membranes have been ruptured many hours, or after a number of vaginal examinations have been made, we believe that it can be performed with relative safety after the patient has had 10 to 15 hours of labor even though the membranes have been ruptured for several hours, provided no vaginal examination has been made and the labor has been conducted with care. Our observation of these patients during a real test of labor also taught us that it is possible in the majority of borderline cases to tell whether or not the head will enter the pelvis long before a full test of labor has been completed. From the experience gained during this second period, we accordingly learned that: (1) even the low cesarean section is not safe when it is done too late in labor, long after the membranes have been ruptured and vaginal manipulations have been made. (2) The low cesarean section can be done after 10 to 15 hours of labor even when membranes have been ruptured several hours if no vaginal examinations are made and a good technique is followed throughout trial period. (3) That a full test of labor is not necessary in the majority of borderline pelvic contractions.

After having thus learned the limitations of the low cesarean section, the risk in pelvic dystocia was considerably diminished in the third period by eliminating the complete test of labor in the majority of cases in which it formerly was used, and by substituting for it a trial labor which was not to exceed 15 hours whenever cesarean section was contemplated. Since this change marked the inauguration of our present routine, I shall now discuss our present teaching concerning the management of pelvic dystocia.

Diagnosis. Until recently the diagnosis was made by means of external and internal pelvimetry exclusively and this means of ascertaining the size of the pelvis is still the only method available to most practitioners. The ordinary external measurements, because of their marked variations in women with normal pelves, are of little or no value, unless they are markedly contracted, except as a means of differentiating between the different types of contraction. More important are the diagonal conjugate which extends from the inferior margin of the symphysis to the promontory of the sacrum, and the biischial diameter which lies between the ischial tuberosities. If the diagonal conjugate measures 11.5 centimeters or over, the inlet of the pelvis in all probability is ample and engagement of the head may be anticipated unless the child is larger than normal. Likewise the outlet is usually sufficiently large whenever the biischial diameter exceeds 8 centimeters. Unfortunately, much experience is necessary before these measurements can be made with any degree of accuracy. For this reason, many errors are made in ordinary practice and cases of pelvic dystocia are not recognized until the patient has shown by a prolonged labor that the head cannot pass through the pelvis. This unfortunate circumstance might be avoided if the average practitioner would have competent obstetric consultation to rule out the possibility of cephalopelvic disproportion whenever the head in a primigravida is not fixed in the pelvic inlet at the onset of labor, or whenever the abdomen is pendulous or overriding is present in any primiparous labor. If facilities for satisfactory pelvic roentgenograms are available, the pelvis may be measured according to the method of Thoms or that of Caldwell and Moloy. The results of these roentgenographic studies are so promising that an extension of their use to every sizable community in the country may be predicted. When this occurs, it is to be hoped that every woman will have the size of her pelvis determined by means of roentgenography before she is married or when she becomes pregnant just as she is having

a premarital or a prenatal Wassermann test done at the present time in some states. When this is done, all cases of contracted pelves will have sufficient warning of possible dystocia to lead them to seek the services of a well trained obstetrician for their confinement.

Delivery. Whenever the anteroposterior diameter of the inlet as determined by means of the diagonal conjugate or by means of roentgenography is 8 centimeters or under, the child is delivered by cesarean section before or at the onset of labor, unless the labor is premature and examination shows the head to be small. While it is possible that a living child may be born through a pelvis with a true conjugate of 8 centimeters, the chance of its not going through is so great and the risk of elective cesarean section is so slight that we are justified in resorting to suprapubic delivery at the time when this operation can be performed with the greatest safety.

Unfortunately, most of our cases of contracted pelves have a true conjugate between 8 and 10 centimeters in length. In these the possibility of delivery through the natural passages is always present and becomes greater with each half centimeter increase in the anteroposterior diameter of the pelvic inlet. Because much depends upon the character of the uterine contractions and the malleability of the head, it is our custom to allow women with such borderline pelves to go into labor. Soon after the onset of good contractions an attempt is made to force the head into the pelvis and the cephalopelvic relationship is determined by a modification of the method of Mueller. An assistant makes pressure over the fundus of the uterus and in the axis of the pelvic inlet while the examiner grasps the sides of the head with one hand and attempts to force it into the pelvis. At the same time, he notes by rectal palpation the effect of this maneuver on the descent of the head. If the presenting part can be forced to within a centimeter of the level of the ischial spines, delivery through the pelvis is awaited. If, on the other hand, the head cannot be forced into the pelvis and a considerable portion of it overrides the symphysis pubis, the child is delivered by a low cesarean section. When the head cannot be forced into the pelvis and little or no overriding is present, labor is allowed to continue in the hope that sufficient molding may occur to permit engagement. Several hours later, this maneuver is repeated and the relationship of the head to the pelvis is again determined. If at that time, no progress has been made, and the true conjugate is less than 9 centimeters, suprapubic delivery is decided upon. When the measurement is 9 centimeters or over, the trial labor is continued even though no progress has been made. From this it may be seen that cesarean section is favored whenever there is no progress and the measurement is only slightly above the upper limit for an elective operation, while delivery through the passages is anticipated in all other borderline cases. This trial labor, however, is terminated within 15 hours after the onset of labor and within 4 hours after the membranes have ruptured in all cases in which cesarean sections are contemplated. In other words, the decision either for or against cesarean section must be made at some time within these limits. Stereoscopic roentgenographic observations during the course of a trial labor are of value. As the use of this method is extended and our experience grows, these accurate roentgenographic studies should assist greatly in the management of difficult borderline cases.

In outlet contractions, the posterior sagittal diameter is measured. Whenever the sum of this measurement and the biischial diameter is under 15 centimeters, elective cesarean section is done. Here again, the more accurate roentgenographic techniques offer considerable help in that they correctly show the length of the symphysis, the acuteness of the subpubic angle, and the size and shape of the sacrosciatic notch. Their use, accordingly, may prevent some of the cases of "failed forceps" which occasionally result from too great a narrowing of the posterior region of the pelvis.

When the routine outlined is followed in the management of labor in contracted pelves, most women are delivered through the natural passages. Labor is conducted in the usual manner with the exception that vaginal examination is avoided and rectal examinations are restricted whenever the possibility of cesarean section is considered.

Forceps may be required as they may be required in any labor and the indications for their use do not differ from the ordinary indications. They are never applied until after engagement has taken place. If it is good practice to refrain from the use of forceps before the head is engaged in cases without cephalopelvic disproportion, it cannot be good practice to apply them when the pelvis is contracted and failure of engagement following a test of labor demonstrates the need for either reducing the size of the head or delivering from above. Forcible efforts to drag a head through a pelvis that is too small cause irreparable damage to the mother and result in the death of the child. High forceps, accordingly, have no place in the treatment of pelvic dystocia.

The fact that the head in breech presentation enters the pelvis with relatively smaller diameters than in vertex cases formerly led some obstetricians to recommend podalic version in the treatment of contracted pelves. While the aftercoming head may be regarded as more wedge-shaped and in rapid extractions should enter the pelvis more readily, it does not have an opportunity to become molded and accordingly is much less advantageous than an oncoming head. The old recommendation that version be done for moderate degrees of pelvic deformity, therefore, is not advised and version is limited to those emergencies which require rapid delivery before the head is engaged but in which the head is thought to be sufficiently small to enable it to pass through the pelvis. For similar reasons, the problem in contracted pelves is more difficult when the breech presents. In these circumstances, the cephalopelvic relationship cannot be ascertained until the aftercoming head reaches the pelvic brim. When marked disproportion is not recognized until this stage of labor is reached, it is too late to consider suprapubic delivery and the child is invariably lost. This inability to study the fit of the head into the pelvis when the breech presents should lead to more frequent resort to cesarean section than has been recommended in the routine suggested for vertex cases.

Induction of premature labor unquestionably assures a larger number of infrapelvic deliveries than the plan outlined but it is accompanied by a high fetal mortality. In many instances, the child is smaller than anticipated and the problem of bringing up a small premature infant is encountered. Since the risk to the mother and child is so slight when the routine described is followed, we believe it to be preferable to one in which a large proportion of the infants are lost. The induction of premature labor, accordingly, has not been considered in our management of pelvic dystocia.

SUMMARY

1. The possibility of pelvic dystocia should be recognized by measurement of the pelvis during the prenatal period.

2. External measurements are of little value in determining whether a pelvis is or is not contracted.

3. The diagnosis depends upon the length of the diagonal conjugate and the biischial diameters, or upon the measurements obtained by one of the accurate roentgenographic techniques.

4. It is to be hoped that every woman will have the size of her pelvis determined by means of roentgenography before she is married or when she becomes pregnant just as she is having a premarital or prenatal Wassermann test done at the present time.

5. Elective cesarean section is advised when the true conjugate diameter is 8 centimeters or under.

6. Borderline cases of pelvic contraction are given a trial labor and the decision either for or against cesarean section must be made within 15 hours after the onset of labor and within 4 hours after the membranes have ruptured.

7. The use of stereoscopic roentgenographic studies in the course of the trial labor is advised.

8. A full test of labor is not necessary in the majority of borderline pelvic contractions.

9. The low cesarean section is not safe when it is done too late in labor, long after the membranes have been ruptured, and after vaginal manipulations have been made.

10. It is a relatively safe procedure when it is done within 10 to 15 hours after the onset of labor and within 4 hours after the membranes have ruptured, provided no vaginal examinations have been made and a good technique has been followed throughout the trial labor period.

11. A destructive operation sometimes requires more skill than is required for the performance of a cesarean section.

12. A destructive operation cannot always be done in a neglected case of pelvic dystocia without risk to the mother.

13. Even in neglected cases, cesarean section often can be performed successfully but the risk to the mother is too great to warrant its use in such circumstances if she can be delivered by any less dangerous procedure.

14. High forceps, podalic version, and the induction of labor are not recommended in the management of contracted pelves.

TOXEMIAS OF PREGNANCY

HERMAN W. JOHNSON, M.D., F.A.C.S , Houston, Texas

THERE are only 2 toxic states due to pregnancy: hyperemesis gravidarum and eclampsia. The only factor in common is that both are ovular in origin; that is, both have their inception in placental tissue, but because of the time of inception in the short life span of chorionic tissue, the substances formed and the symptoms resulting are as different as those from ingestion of unripe and overripe apples.

While placental tissue remains such from the first thread-like villus to senescence, it undergoes remarkable changes in the rate of cell proliferation, function, and appearance. An animated picture of the first 10 weeks of placental development would display action above all else. It rapidly attains a high weight ratio of ovular tissue to embryo. This ratio is reversed later but in a more gradual manner. There is marked proliferation of chorionic epithelium, rapid development of ferment bearing cells, and arrangement of the syncytial cells over the layer of Langhans. There is also complex structural arrangement of the villi permitting osmosis with the maternal circulation. Real early the placenta, in addition, takes on with the pituitary the function of the formation of a gonadotropic hormone. It is during this embryonal period of the placenta that hyperemesis develops. It is during advanced age and senescence of placenta that eclamptic toxemia develops.

For a number of years it has seemed to the writer that the most tenable thesis as to the etiology of hyperemesis is that during this period of rapid development of the placenta, a specific protein substance, of which the syncytial cells may be the chief component, is thrown into the maternal circulation. This protein substance, which is exogenous, could produce the symptoms; the ovum is parasitic. This protein substance might act by reason of its molecular structure, its lytic action, or by possessing agglutins, as it might in cases of incompatible blood groups in parents.

If the foregoing could be the basis for moderately severe nausea and vomiting, one might postulate that in an allergic individual, the extreme sensitivity to foreign proteins, combined with dehydration, starvation, and vitamin deficiency, could produce the pathology found at autopsy in death from hyperemesis gravidarum. If the obstetrician will question patients with hyperemesis, he will be surprised to find out how frequently he can elicit a history of allergy in the patient or her antecedents. Several years ago the writer made an attempt to desensitize these patients by injecting blood serum from the husband. The results were not satisfactory enough to warrant the continued annoyance to the husband or the loss of time spent in procuring, keeping, and giving the serum. Later a sterile milk preparation was used with about the same result. Since then much progress has been made by the allergist in the method of desensitization. It may be that their services can now be enlisted so that this method of treatment can be given a fair trial.

The psychogenic factor in hyperemesis must always be taken into consideration; but the assumption that it is the sole cause is as unscientific as it is unfair and unsympathetic. It can be seen readily that economic stress or failure of social or marital adjustment might be the conscious or subconscious motive for not desiring the pregnancy. It is an interesting fact that many of my patients with hyperemesis have been unusually bright women with slight paranoid personalities. In other words, it is the potential career woman who probably subconsciously rebels at the self-negation of marriage, and the prospect of complete nihilation with reproduction. I am unwilling to admit that even in these cases the psychogenic factor was the sole cause. To conclude that the vomiting which was carried on to dehydration, starvation, and death was produced solely by a psychogenic factor, would require that the autopsy of this patient be the same as the autopsy findings in cases of starvation.

ECLAMPTIC TOXEMIA

We believe that pre-eclampsia, as characterized by hypertension, is caused by proteinogenous amines, especially tyramine; and that eclampsia, characterized by hypertension plus capillary spasm, is an allergic reaction to the same amines.

Young, in 1914, was the second worker to point out the significance of placental infarction with reference to toxemia. Young contended that cell autolysis in the infarcted area eventuated in split proteins which caused the symptoms. In 1927, 1928, and 1929, Dr. H. O. Nicholas, head of

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Department of Biochemistry, Rice Institute, Dr. Robert A. Johnston, my associate, and the writer, (20, 21, 22) started in where Young left off with his split proteins, and began biochemical analyses of the blood, urine, vomitus, and placentas from eclamptic patients. We took advantage of the exhaustive work of Hanke and Koessler (1-19) on proteinogenous amines, which was done at the University of Chicago from 1921 to 1926. This work will be referred to later. Specimens were first examined for histamine, the ideal endothelial toxin, but Dr. Nicholas was never able to get a positive reaction. Tyramine was next, and the first reaction was obtained from material gathered by gastric lavage. This had been done at the suggestion of Dr. Caldwell, who stated that whatever the toxin was, the gastric mucosa was instrumental in its elimination. This was followed later by positive tyramine reactions for this eclamptic's blood, placenta, and urine. In 1936, Muller and Govaerts found tyramine in the blood serum and cerebrospinal fluid of eclamptic patients. Also in the same year Leoper and Lesure found tyramine in the blood serum in cases of hypertension. For our purposes we appropriated that part of the work of Hanke and Koessler on proteinogenous amines which showed that there are strains of pathogenic bacteria which, in culture media, converted histidine into histamine, and tyrosine into tyramine. This conversion was due to enzymic action. Pure strains were specific in action; that is, an organism capable of producing tyramine could not produce histamine and vice versa. Over 80 organisms were found to possess this quality, notably various strains of Bacillus coli and Streptococcus hemolyticus.

Any theory as to the etiology of eclampsia must explain the commonly observed facts, namely: it occurs only in the human female; a placenta must be present, or a symptom continuity with a placenta; the condition is more common in primiparas, twins, overweight babies, and polyhydramnios; its incidence increases during or following respiratory epidemics; and it follows severe Bacillus coli infections too frequently to be accidental.

It is our theory that the upright position, which is maintained only by the human female, often causes venous back pressure, as shown by varicose veins, hemorrhoids, varicosities of vulva, vagina, and broad ligaments. This venous back pressure of the upright position is a factor under certain conditions of pressure in causing alterations in the uteroplacental circulations, that is, stasis in the intervillous spaces. These conditions are, first pregnancies, late pregnancies, large babies, and polydramnios. When these areas of stasis develop and are maintained for some time, the chorionic cells are deprived of nourishment and die. Cell autolysis then follows. The chorionic tissue is reduced to its amino-acid content, just as liver tissue is reduced in acute yellow atrophy with the production of amino-acids. Let me say here for the purpose of clarifying our so called "circulatory insults," of which infarction is often the visible result, that we do not give infarction the importance which we formerly did. Dr. Nicholas found that tyrosine accounted for 4.26 per cent of the dried weight of placental tissue. Hence, a few scattered areas of stasis with cell autolysis would produce adequate tyrosine. If this intervillous stasis with its consequent destruction of chorionic tissue is extensive, hemorrhage takes place in this area. This hemorrhage is probably a protective mechanism by the fetus for the destruction and removal of destroyed tissue from channels of absorption. However, such parts of the affected area contiguous to the intervillous spaces may have been the source of the tyramine which produced the symptoms. In other words, eclampsia does not require visible infarction. A placenta without visible infarction from an eclamptic toxemia will show tyramine. Therefore, it can be inferred that the different areas of stasis were the source of the tyramine.

Reverting to the area of chorionic cell autolysis with its reduction to amino-acids, it must be admitted that even if the absorption of these amino-acids were rapid, their effect would hardly be toxic. The circulation, unless the liver is completely destroyed, can take care of these without difficulty. They must be converted into their respective amines in order to become toxic.

Source of the toxin. The ability of bacterial enzymes to convert amino-acids to poisonous amines gives a possibility of conversion in the placenta under conditions previously outlined. We are anxious for this to be so, because with the placenta as the source of the toxin, which we firmly believe, it is easier to explain certain frequently observed and well known facts. Naturally, one would think the source of the tyramine found in the blood stream and the placenta to be from the intestinal tract, especially the colon. But on investigation it is found that though tyramine is formed in the large intestine, due to its affinity and attachment for small particles contained within the lumen of the bowel, practically no tyramine or histamine passes through the mucosa into the portal vein. *In extremis* it does, but the onset of pre-eclampsia is not *in extremis* in the patient. If small quantities of tyramine do get into the portal vein and to the liver, it is

quickly de-aminized by a tyramine oxidase. With these difficulties to surmount, especially with a well patient, it is not easy to prove that the tyramine in the blood had its source in the large intestine.

Reverting to the placenta as the source of the toxin, the following facts are significant: A human female, and a living placenta, or a symptom continuity with a placenta is absolutely essential to eclampsia. If and when the toxin is formed in the manner heretofore outlined, its permeability and absorption depend on the normal, uniform pressure between the area of formation and the intervillous spaces. That absorption does not take place otherwise is shown by the improvement following death *in utero*, with rapid absorption of the amniotic fluid. Rupturing the membranes is followed by improvement. Here again with the lowering of the intra-uterine pressure, but with the placental circulation still functioning, there is not such a disturbance in the uniform pressure. There is further proof that the placenta is the source of the toxin. Improvement rapidly follows the birth of the placenta. While toxemia generally affects the baby to a less extent than the mother, we reported a case of eclampsia in a newborn in which hypertension in the mother had escaped detection.

Tyramine is a toxic amine with a pressor action. It is somewhere between histamine, the universal irritant, and guanidine which, no doubt, is much milder in action. Chemically, it is quite similar to the physiological amines, adrenalin, pitressin, and pitocin, and also similar in action to the amino-acid thyroxin. The hypertension from tyramine is primarily the result of direct irritation to the vasoconstrictor terminals of the capillaries, and secondarily to irritation of the glomeruli of the kidney. It is possible that after de-aminization of the tyramine, the irritation to the glomeruli continues the hypertension until this irritation has subsided. This accounts for the hypertension prior to the appearance of albumin and the continued hypertension longer than the pharmacological action of tyramine would produce.

In former papers we have reported experiments of injecting into the peritoneal cavity of dogs extracts of sterile placental tissue and of incubated non-sterile placental tissue. We have also reported the production of peripheral necrosis in dogs by injecting large doses of tyramine into the portal circulation. We have reported the time required for the de-aminization of tyramine in the circulation of dogs and also in the human. We have reported the production of the characteristic occipital and frontal headache of pre-eclamptic toxemia in the human. We have also reported the tyrosine content of dried placental tissue, and have shown that the amount of tyrosine in approximately a dram's weight of dried tissue would be lethal if rapidly converted and absorbed. Our last paper (25) gave the following conclusions:

1. With our present methods of blood protein precipitation and analysis we cannot at this time describe any blood chemistry picture peculiar to eclampsia, involving variations in non-protein nitrogen, urea, uric acid, amino-acids, or creatine.

2. There does not seem to be any increase in the undetermined nitrogen fraction of the non-protein nitrogen content which might indicate the presence of large amounts of toxic amines.

3. Tyramine seems to be the only amine definitely associated with the clinical symptoms of eclampsia. Also, the amount of tyramine does not seem to be directly connected with the severity of the clinical symptoms.

The last part of paragraph 3 of our conclusions was best explained by inferring that the difference between the quantity of tyramine in the blood and the symptoms exhibited by the patient was due to allergy. No facts had been gathered to support this inference. During the past year a weak attempt has been made by the writer to assemble such information as would throw light on the question. A brief statistical study of late toxemia shows that approximately 10 per cent of pregnancies at or near term exhibit various degrees of hypertension, 2 per cent develop moderately severe toxemia, and eight tenths of 1 per cent exhibit hypertension plus capillary spasm. For purposes of this paper evidence of capillary spasm is limited to angiospasm of the retinal arterioles and convulsions. The visual disturbance of retinal angiospasm is well known. It is an assumption that convulsions are due to a sensitive cortex with angiospasm and edema. If some cases of excruciating headache, abruptio placentæ, generalized edema, and marked albuminaria were added, this group would be over 1 per cent.

An investigation to support the allergy theory would include: First, history of allergy in patient or antecedents; second, evidence that the substance investigated ever produces allergic reaction; third, skin testing. In order to elicit a history of allergy, a voluminous questionnaire must be prepared and interpreted by an allergist. Information from this source was abandoned. It is interesting, however, to note that casual questioning of a toxemic patient will bring forth from the patient or mother some first-hand information about "uremic poisoning." There is some evidence that we have eclamptic families as well as asthmatic families. The writer knows a family in

which 3 of 4 daughters had convulsions with the first pregnancy. Chen, whose pharmacological studies were conducted on dogs, gave a man some tyramine acid phosphate by mouth. This was followed later by an extensive urticarial rash. We are all familiar with the urticaria which occasionally appears in a patient convalescing from eclampsia. The same character of rash is often noted in babies born of eclamptic mothers.

The skin testing was done after invoking the aid of an outstanding allergist. It wasn't long before the writer could see that he was being taken into unknown fields, fields of anaphylaxis, atopic reactions, transferred sensitivity, etc., etc. To the writer the question seemed more simple: Does a given solution of tyramine, with a known hydrogen ion content, when given intradermally to different people, produce a reaction with slight individual differences, or a reaction with marked differences? Naturally, the identical solution must be given to the individuals, the amounts given must be the same, and the gauge of needle the same. Methods of the allergist can be used then in interpreting the reaction-size of wheal, pseudopods, extent of erythema, or flare, and duration of reaction. This, then, may be indicated from 1 plus to 4 plus. Normal saline was used for control. The solutions of tyramine hydrochloride, were marked 2, 3, 4, and arranged from .002 to .00002. The quantity given was two one hundredths of a cubic centimeter; the gauge of needle was 27.

Twenty patients have been tested. In the majority of cases, patients were selected who had had or were suffering from hypertension plus capillary spasm, and also patients with marked hypertension alone. The number of cases has been small and this is only a preliminary report. No claims whatever are made, but the tests seem to indicate that those who have hypertension with capillary spasm show marked sensitivity to very weak dilutions of tyramine.

SUMMARY

The suggestion is made that the specialty of allergy may be instrumental in solving the etiology of hyperemesis gravidarum.

The theory regarding eclamptic toxemia which we have tried to support requires that: (1) stasis in the intervillous spaces must be of sufficient duration to cause degeneration of chorionic tissue, with the production of tyrosine; (2) that only through infective processes with bacteria or enzymes circulating in the blood is the conversion of tyrosine to tyramine possible; (3) the absorption of the tyramine formed depends on the condition of uniform pressure as outlined in the paper; (4) tyramine circulating in the blood in pregnancy produces only hypertension; and (5) in the sensitive or allergic patient, tyramine produces hypertension, plus capillary spasm which is the pathological unit of eclampsia.

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SYMPOSIUM: OTORHINOLARYNGOLOGY

LARYNGECTOMY: A PLEA FOR A NARROW FIELD OPERATION

CHEVALIER JACKSON, M.D., F.A.C.S., Philadelphia, Pennsylvania

HISTORICAL matters would be out of place in this paper. Moreover they have been extensively reviewed in a recent publication in which I collaborated (11). A few historical phases must be mentioned here because their persistent remnants seem to frustrate efforts at certain improvements in technique. A few of the historical errors of which we inherit remnants are the following:

1. Laryngectomy during the first 27 years of its recognition as a practicable operation was done only in advanced cases of malignant disease of the larynx. In not one case does the history show that there was an early diagnosis.

2. In all cases the growth was extrinsic by origin or extension.

3. Biopsy was not done.

4. Direct laryngoscopy was ignored.

5. Great store was set by the presence of hard lymph nodes as a diagnostic feature and laryngectomy was seldom done in their absence.

6. Surgeons were misled by applying to the larynx the principles developed in the operations for cancer of the mamma and axilla, regions quite different anatomically and pathologically from the larynx. In operable cases of cancer of the larynx we are dealing with squamous cell carcinoma and it is inside a cartilaginous box with 2 layers of perichondrium, which constitute 3 barriers that do not exist in the mamma. If we do a laryngectomy at the early period at which it should be done, we take out that box and its contents before leakage has occurred.

7. Practically all laryngectomic techniques were based upon search for and removal of cervical lymphatics whether involved or not.

WIDE FIELD LARYNGECTOMY

Under conditions enumerated in the foregoing paragraphs only a wide field operation could afford the ample access necessary. Unquestionably the wide field is easiest for the operator. To lay back huge flaps, open up the whole front of the neck, layer by layer, cut away the muscles, identify the anatomical structures seriatim as in the dissecting room constitute the comfortable way to work. So also would be a lengthy incision for laparotomy.

The disadvantages of a wide field laryngectomy are so many and so vital that it seems proper to raise the question whether or not a wide field is necessary in all cases. These disadvantages are: (1) shock, (2) trauma, (3) impaired blood supply, (4) flaps, (5) air-pocketing, (6) large wound, (7) increased flow of serum, (8) retarded healing, and (9) greater risk of pharyngostoma.

Shock. There seems no reason to question the greater degree of shock in the wide field operation. It seems equally evident that to some degree shock retards healing processes. Otherwise the importance varies with the equation of the particular case.

Trauma. By all the techniques of wide field operation the amount of trauma is necessarily much greater than in a carefully executed narrow field operation. The greater the trauma the greater the time for healing, and traumatized tissues favor sepsis.

Impaired blood supply. Unquestionably a larger wound means more vessels cut, and more hemostasis means prolongation of operative time. But these are of less importance than the fundamental fact that the wide field operation invades a region of greater vascularity extensively as compared to the small anastomotic arterial twigs found in the median line (Figs. 1, 2). Impaired blood supply means retarded healing. Retarded healing invites sepsis in a region where a septic field like the pharynx is concerned in the operation. In such a wound, if healing must await re-establishment of an extensively interrupted blood supply, trouble is almost certain.

Flaps. In a wound exposed to infective risks, such as pertain to laryngectomy, flaps are objectionable inversely as their blood supply. Anemic

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flaps do not become necrotic often but they inevitably retard healing and thus invite infection. To lay back huge flaps gives the surgeon easy and comfortable access to all the anatomical structures in the neck, but the ease and comfort are too often offset by the consequent postoperative anxieties.

Air-pocketing. A wide field, with large flaps and extensive muscular exsections, multiplies the difficulties of eliminating air and serum pockets, and if these are not eliminated they will retard healing and increase infective risks. The stump of an exsected muscle makes a pocket difficult to obliterate.

A large wound. It is true that under aseptic and otherwise favorable conditions a large wound heals as quickly as a small one; yet under conditions present in laryngectomy a large wound, with its lesser support of the pharyngeal repair, greater flow of serum, and increased tendency to air-pocketing, multiplies the risks of infection. When infection does occur the breaking down of the large wound means extensive suppuration, sloughing, and a large area for septic absorption.

Retarded healing. Of course primary union is always desirable and sometimes obtainable after laryngectomy; but what is even more important is that anything that retards healing enormously increases the infective risks. A healthy wound with little trauma and little interference with blood supply has the best chance of prompt healing and the highest resistance to infection. On the contrary, a sluggish wound with large anemic flaps favors the breaking down of the pharyngeal repair.

Pharyngostoma. All of the factors referred to in the foregoing paragraphs add up to a high percentage of pharyngostoma, and especially to large pharyngostoma, which is the most troublesome of all laryngectomic sequelæ.

To the enumeration of all of these disadvantages the objection will be raised that they are unimportant compared to the 100 per cent mortality of untreated cancer of the larynx. This is true, but it does not imply that we should not seek less risky and equally efficient means of dealing with this dire disease.

All that has been said here may be misconstrued as condemnation of a wide field laryngectomy calling for constructive suggestions. With no expectation of general acceptance I venture to make the following suggestions:

1. A narrow field laryngectomy should be done in suitable cases. That is to say, the larynx should be removed through a midline incision without flaps.

2. No search ought to be made for metastatic lymphatics when no nodes are palpable. If evidence of lymphatic involvement should develop after a narrow field operation, exsection can be done as a relatively minor operation free of septic risks; the lymph channels can be sealed up by irradiation; or both of these measures may be combined. Probably large scale averages would be as good as from wide field operation. My opinion is that all metastogenic material cannot be removed from the neck by any operative procedure no matter how radical.

3. When lymph nodes are palpable the case is one for irradiation rather than laryngectomy. My experience in this respect supports the opinion of Crowe and Broyles and a few other laryngologists.

4. A good way to eliminate wide field laryngectomy is to make an earlier diagnosis of cancer of the larynx. A still better way would be to make a diagnosis so early that the cancer would be amenable to treatment by laryngofissure; then the patient would not lose his larynx by either wide field or narrow field laryngectomy. If hoarseness in an adult were considered as probably cancerous and calling urgently for immediate diagnosis, laryngectomy would rarely be necessary. Delay in diagnosis of cancer of the larynx is inexcusable. It can be made early and promptly by biopsy.

To prevent misunderstanding it should be emphatically stated that the narrow field operation is advocated only for early intrinsic disease that is too extensive for the laryngofissure route. It would be a deplorable mistake thus to operate in a case of cancer that is extrinsic by origin or extension, or on a patient with palpable lymphatic involvement. If the surgeon believes in operative treatment of such cases, a wide field operation is necessary.

NARROW FIELD LARYNGECTOMY

By the term narrow field laryngectomy I mean an operation in which the larynx, and the larynx only, is removed through a midline incision. Its greatest advantage is that in most cases it is followed by such rapid healing that the risks of infection, sepsis, sloughing, breaking down of pharyngeal repair, and pharyngostoma are avoided.

Indications. Narrow field laryngectomy is indicated in cases of malignant disease of the larynx in which the lesion is still intrinsic and of limited extent, though too far advanced to warrant laryngofissure.

Contra-indications. A narrow field laryngectomy is not to be considered under the following conditions: (1) a lesion extrinsic by origin or

extension; (2) involvement of the internal perichondrium, even though it be only inflammatory; (3) impairment of arytenoid mobility; (4) any evidence of lymphatic involvement even if only inflammatory. Very careful delicate and deep palpation is necessary to discover lymphatic involvement in some cases. (5) A high degree of malignancy as indicated histologically; (6) general contra-indications to any operative procedure. Though these cannot be ignored they are less important than in a wide field operation because shock is much less. My opinion is that laryngectomy is contra-indicated in a patient who, apart from cancer, would be rated as having less than average life expectancy, as judged by actuarial standards.

Technique of narrow field laryngectomy. In presenting the following statement of a few of the basic technical features of the narrow field operation it should be emphasized that they are not intended to apply to a wide field laryngectomy. It is hoped this will be borne in mind in discussion.

1. One absolute essential is good illumination; it must be equal to and not unlike that required for intranasal surgery. The ideal is a beam projected into the wound nearly parallel to the operator's visual axis.

2. In the choice of an anesthesia, the operator is free to follow his preference except for the following restrictions: Infiltration is objectionable because of local trauma if perfect analgesia is obtained. Inhaled ether is objectionable because of bronchial hypersecretion. Profound, prolonged anesthesia of any kind is objectionable. The shorter the time the cough reflex is abolished the better. If morphine is used at all, it must be in one small dose before operation and not repeated, so as not to interfere with prompt restoration of the tussive reflex. Atropine should not be used.

These restrictions narrow the choice to chloroform (5, 22), nerve block (18, 19), and the group of drugs represented by avertin (1, 17). Light chloroform insufflation has many advantages, but it must be administered by an anesthetist not only experienced but enthusiastic in its use.

3. A median line incision that goes through only anastomotic arterial twigs is made (Figs. 1 and 2). It should extend from the hyoid bone to the suprasternal notch. If emergency or anatomical anomaly should require it, the incision can be extended upward by median division of the hyoid bone, as in the New operation. No transverse incisions are made.

4. No flaps are dissected up; the integument is left normally attached to deeper structures. The median incision is deepened by clean cutting until

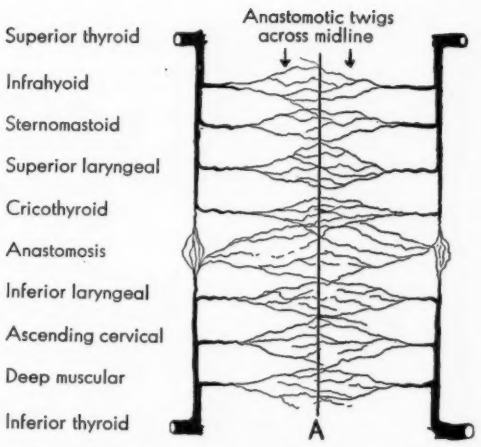

Fig. 1.[1] Diagram of the arterial supply of the tissues concerned in laryngectomy. The supply comes from lateral trunks, chiefly the superior and inferior thyroid arteries. The upper and lower trunks anastomose freely with each other and also across the midline to the corresponding vessels of the other side. Obviously a narrow midline wound, (*A*), for laryngectomy, dividing only anastomotic twigs, leaves a better blood supply than a layer-by-layer operation as shown in Figure 2.

the larynx and trachea are reached. Retractors are used carefully so that the whole sides of the wound are retracted and not the skin alone.

5. Utmost care should be taken to minimize trauma; cutting is preferable to blunt dissection. Traumatized tissues are vulnerable and invite infection.

6. Few ligatures will be required; no large arteries are normally present in the midline (Figs. 1 and 2). Veins of considerable size may be encountered; if they cannot be drawn aside, they should be clamped before division and ligated at once. The superior and inferior laryngeal arteries, or their anomalous equivalents must be ligated, and also their accompanying veins. In all of this work trauma should be carefully minimized as advised by Crowe and Broyles.

7. Muscles are not exsected as in wide field laryngectomy. It is true that the muscles inserted into the laryngeal cartilages lose their insertion; but they are not useless; their action after healing assists in swallowing movements and sometimes in pseudophonation. What is even more important is the fact that leaving the muscles lessens trauma and pocketing and gives good support to the pharyngeal repair. Muscular insertions into

[1]Figures 1 and 2 to be used in *Cancer of the Larynx*. Philadelphia W. B. Saunders Co., in press.

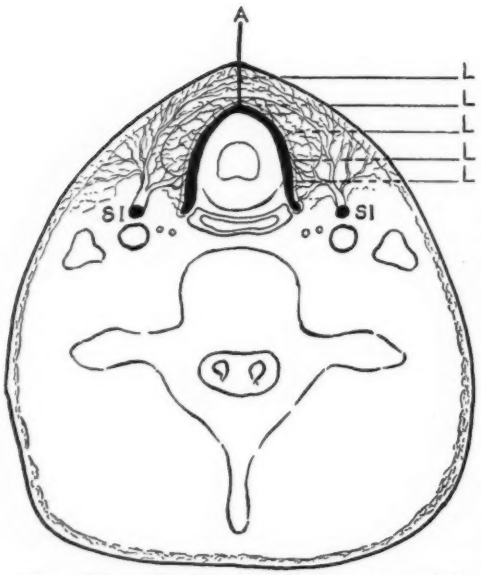

Fig. 2. Diagrammatic horizontal representation of the blood supply of the region concerned in laryngectomy. (It does not represent a frozen section at a particular level, but a composite schema of the different levels concerned.) The blood supply is chiefly from upper and lower lateral trunks, represented compositely at *SI*. Obviously a midline wound, *A*, as in a narrow field laryngectomy, leaves a better blood supply, with consequent better chances for prompt healing, as compared to a layer-by-layer operation (*L, L, L, L, L*) with laying back of large skin flaps and much hemostasis. Pending development of a collateral circulation healing is retarded and pharyngostoma is favored, and sometimes even necrosis of flaps occurs.

the laryngeal cartilages are detached close to the perichondrium with least possible trauma. Detaching the perichondrium itself with insertions intact, as done by Crowe and Broyles, seems even better.

8. Mechanical aspiration of blood and secretions must be maintained as long as the cough reflex is abolished.

With the aforementioned technical features constantly in mind, the operator may use his favorite plan of removal of the larynx. He may remove it from above downward or from below upward as preferred.

9. Not having exsected any muscles good, strong support for the pharyngeal repair can be built up. The stiffening of the repaired wall is increased by the thyroid perichondrium if the plan of Crowe and Broyles be employed.

10. The median line incision without muscular excisions or pockets simplifies drainage. There is ordinarily no need of riddling the neck with passages for drainage tubes. One median drain is usually sufficient. Crowe and Broyles use rubber tissue. Babcock prefers glass and uses continuous suction with a weak motor pump.

11. At the top of the order sheet after operation should be written, "This patient must not be given atropine or opiates without written authorization of the chief." If this is not done, the deplorable hospital routine of postoperative sedatives will inevitably be followed. Water in adequate daily amounts to prevent dehydration must be specified. It is given through the nasal feeding tube that is placed at operation. Food is unimportant for the first day, but water is vital. After the first day vitamins and a balanced diet are essential for prompt healing.

12. Dressings should be heavy enough only to cushion the pressure needed for obliteration of pockets. A frequent change of gauze prevents stagnation and the flow of sterile serum cleanses the wound. Catheter aspiration of the trachea by the nurse prevents obstructive atelectasis. If the percussion note becomes impaired over any area of either lung, notwithstanding catheter aspiration of the trachea and main bronchi, bronchoscopy must be done for clearing the airway. Under no circumstances is a diagnosis of pneumonia warranted without a bronchoscopic examination to exclude obstructive atelectasis. If a tracheal cannula is worn, the outer cannula must be changed at least once a day and the inner cannula as often as necessary. The Chevalier L. Jackson cannulas without entangling projections are best because they prevent jars and jerks on the wound in wiping away coughed-up secretions.

POSTOPERATIVE COMPLICATIONS OF LARYNGECTOMY

The appalling frequency and high mortality of complications in the early days of laryngectomy have been greatly diminished by modern technique of wide field laryngectomy and still further lessened by the narrow field technique, yet it cannot be said that complications have been eliminated altogether. It seems warranted to state that the narrow field procedure is seldom followed by secondary hemorrhage, virulent infection, serious sepsis requiring opening of the wound, necrosis, sloughing, breaking down of the pharyngeal repair, pharyngeal fistula, or pharyngostoma. Pulmonary complications require separate consideration.

Pneumonia and atelectasis as complications of laryngectomy. Pneumonia as the internist understands the term, is, today, one of the rarest com-

plications of laryngectomy. In the early years of this operation, according to the records, about 40 per cent of the patients died of "pneumonia," "double pneumonia," or "collapse." The bronchoscope has shown that recorded signs and symptoms of these conditions have been produced in patients who had obstructive atelectasis without pneumonia and, further, that all of the signs and symptoms disappeared after plugs of thickened secretion were bronchoscopically removed (8, 9, 11–15). Because of its bearing today on the problems of laryngectomy and its postoperative care, it seems important to make an analysis of the factors concerned in the obstructive atelectasis that so frequently was, and occasionally is still mistaken for pneumonia. First, let us consider the operative procedure and after-care practiced in the early days. They have been enumerated thus:

> "The pall of the earlier days still hung over the operation. In the usual technic the patient was kept profoundly under the anesthetic because surgeons believed light anesthesia involved risk of sudden reflex cardiac arrest. The practice was to start with a deep anesthesia which totally abolished the cough reflex for two or three hours, then to give opiates which abolished it for a number of days longer. Though full physiological cough cannot be carried out without glottic co-operation, the laryngectomized patient can, by forced expiratory blast, clear his tracheobronchial tree through the cannula if his secretions are not thickened by opium and atropine and all his sensory nerve endings and reflexes are not drugged asleep. Strange as it may seem, many operators deliberately gave large doses of atropine for the purpose of drying up the saliva with no thought of the harm to the lungs. Stagnation of pulmonary secretions and clots for two or three days resulted from the drugging asleep of the watchdog of the lungs."(11)

Let us consider some of the factors that were concerned in the desiccation of the bronchial secretions and consequent obstructive atelectasis due to plug formation.

1. *Ether* was blamed for causing postoperative "pneumonia" by direct irritation. It probably never caused pneumonia in this way. It is a factor in bronchial plug formation in 2 different ways. (a) It causes hypersecretion. The bronchoscope has shown that when there is hypersecretion the secretions increase in coagulability because of an increase in fibrin (9). (b) Ether is a powerful respiratory stimulant; during a long operation the respiratory centers are greatly fatigued; a long period of reactively weakened respiration follows. This means stagnation of the excessive endobronchial secretion. Stagnation favors thickening and coagulation.

2. *Dry air.* Thickening of endobronchial secretions and plug formation are favored by the dry air of the average hospital; in winter time hospital air is desiccating (11, 12, 14). This desiccation is of course increased by the fact that the inspired air in the laryngectomized patient is taken in directly through the neck without the humidifying effect of the nasal passages.

3. *Dehydrated condition of the patient* favored drying of endobronchial secretions. The patient was deprived of water because the operator feared the necessary swallowing movements and pharyngeal distention might start a leak in the pharyngeal repair; or the water reaching the stomach might cause equally disastrous vomiting. This latter was almost certain to happen because of the opiates given. The nasal feeding tube advocated in 1904 (10) to prevent dehydration as well as for feeding, was likewise objected to as mechanically causing nausea that was really due to opiates.

Opiates and atropine. Atropine was routinely used (a) separately for its inhibitory effect on oral secretions that often threaten to break through the pharyngeal repair; (b) to lessen bronchial hypersecretion of ether inhalation; (c), as an adjuvant to morphine. Unquestionably atropine favors thickening of bronchial secretions and formation of plugs that cause obstructive atelectasis. Morphine or any other opiate has the effect of drying the bronchial secretions, depressing respiration, and inhibiting the cough reflex, thus favoring stagnation and drying (6, 7, 8, 9, 15).

Abolition of the cough reflex supplied the important element of time for the coagulation, thickening, and increased viscosity of secretions and thus favored formation of obstructive masses or plugs. Uninhibited cough, by the bechic blast and tussive squeeze would have expelled the fluid secretions before they had time to undergo an increase of viscosity. By all the classic techniques the cough reflex is abolished by the anesthetic during the long operation; this abolition is perpetuated by the postoperative administration of morphine and atropine.

Recurrence. Ultimate statistics are not yet available in sufficient quantity for even approximately conclusive determination of relative percentages of recurrence in wide field and narrow field laryngectomies, respectively. So far as early recurrences are concerned they are fewer after the narrow field than after the wide field operation. This, however, does not indicate that the narrow field technique is necessarily more efficacious; it was used only in less advanced cases and those not showing evidence of glandular metastases.

SUMMARY

The following statements though dogmatic in form are offered as postulates:

The standard technique of laryngectomy is based upon extensive removal of lymphatic metastases. The advisability of attempting to remove such metastases seems questionable; but, granting that it is advisable, are we justified in opening the whole front of the neck to get out the larynx of a patient who has no glandular involvement? Let us call this technique a wide field operation. Unquestionably, it is the easiest way to operate because of its wide access. Its disadvantages are extensive trauma, much interruption of blood supply, poorly nourished flaps, retarded healing; and all 4 of these disadvantages combine to favor breaking down of pharyngeal repair and formation of pharyngostoma. Is it not better to do a narrow field operation, taking out the larynx through a midline incision and leaving the apparently uninvolved glands to be sealed up by irradiation if they should later show evidence of involvement? The history of the surgical treatment of cancer of the larynx shows that operators have closely followed the principles developed for dealing with cancer of the breast where anatomical and pathological conditions are quite different. In dealing with mammary cancer a narrow field operation would be indefensible. In cancer of the larynx too advanced for laryngofissure, but still intrinsic and free from evidence of cervical adenopathy, a narrow field operation seems to have many advantages.

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THE DIAGNOSIS AND SURGICAL MANAGEMENT OF CHRONIC SINUSITIS

W. RAYMOND McKENZIE, M.D., F.A.C.S., Baltimore, Maryland

THE correct diagnosis of chronic disease in the paranasal sinuses can be arrived at only by a definite and systematic routine of study. Failure to adopt such a plan will add unnecessary handicap to one's efforts and may even lead one astray entirely. It is only by the strict observance of every detail that an accurate diagnosis can be obtained. Any inaccuracy in diagnosis will undoubtedly lead to improper treatment. This is one factor which is responsible for the attitude of the laity and of many physicians, who are opposed to nasal and sinus surgery or treatment. The so called conservative surgery on the nose and sinuses is, I believe, a larger factor in the distribution of the propaganda that "once a sinus, always a sinus." The removal of the septum, a turbinate, or a polyp for the cure of chronic sinusitis is as efficient as a skin incision for the cure of appendicitis. Unless the abdominal cavity is entered and the diseased appendix removed, a cure cannot be expected. Likewise unless the sinus cavity or cavities are opened and the diseased tissue completely removed, good results cannot be obtained.

NEED OF ACCURATE DIAGNOSIS

First in importance in any diagnostic study is a well taken history. This will provide all the facts about the onset and the progress of the disease. It will eliminate or lead to suspicion allergy or allergic tendency. This is a most important point and should always be given due consideration, otherwise too many disappointments will result.

The symptoms elicited in the history are all significant. Headache or pain is a frequent symptom, occurring in about 60 per cent of the patients. However, the fact must not be overlooked that pain is not an essential symptom of chronic sinus disease. The worst types of sinusitis can exist for years without any pain whatsoever. This is especially true in ethmoid and antral involvement, less likely to occur in frontal or sphenoidal infection. While the pain varies greatly in severity, location, and character, it still has some diagnostic significance. There may be days or weeks of complete freedom from pain, followed by days or weeks of excruciating pain, which morphine will relieve only partially. It may be moderately or mildly severe and described as a sense of pressure or fullness inside the head, or of a band drawn tightly around the head. It may be constant, or intermittent and neuralgic in character. It may be frontal, parietal, occipital, or all over the head, or referred to the ear or throat and larynx. The intermittent or neuralgic type of pain usually exhibits one characteristic. It begins during the morning hours or the patient may be awakened with it. It grows in severity and intensity for 2 or 3 hours, and then gradually subsides completely, so that towards evening and at night the patient is absolutely free of pain. It recurs at the same time and in the same location the next day, and every day as long as the attack lasts. The diffuse, generalized headache, whether occurring in the frontal, parietal, or occipital region, shows constancy only in that it recurs in the same location and shows no tendency to migrate.

Location, character, and severity of the pain are not always significant of the sinus or sinuses involved, or of the degree of involvement. It is very important to bear this fact in mind so that a healthy sinus will not be opened unnecessarily, because of a diagnosis arrived at through pain localization. Frontal headaches are due much less frequently to frontal sinusitis than to ethmoidal or antral involvement. The vast majority of patients complain of frontal headaches, while only 2 or 3 per cent have frontal sinusitis. Pain in the

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occipital region and referred down the back of the neck is most frequently due to sphenoidal sinusitis. Pains in the frontal region, in and about the eye, over the parietal region, or pain referred to the ear and mastoid region, or the throat and larynx are almost always ethmoidal and maxillary in origin and are due most frequently to sphenopalatine ganglion irritation.

Nasal or postnasal discharge is the most frequent complaint. While annoying or disagreeable, it is not likely to be a compelling reason in the search for relief. In a small percentage of patients it is the principal symptom. In others, it is more or less taken for granted, considered normal and natural, and not mentioned until the question is asked. Between 80 to 90 per cent complain of postnasal dropping, about 40 to 50 per cent of anterior nasal discharge, either unilateral or bilateral. The amount and character of discharge varies greatly. The patient may soil from one to a dozen or more handkerchiefs a day. The discharge is usually frankly purulent or mucopurulent. It may be constant or intermittent with varying periods of freedom. Each exacerbation or recurrence of the discharge is frequently considered a "fresh cold" by the individual. If recurrences are not accompanied or characterized by a purulent or mucopurulent discharge, allergy should always be suspected.

Nasal obstruction accompanies about 50 per cent of cases of chronic sinusitis. This may be due to deflected septum, very thick, tenacious discharge, swelling of the nasal mucous membrane and turbinates, polyp formation, or a combination of any or all of them.

About 30 per cent of individuals suffering from chronic sinusitis will have pulmonary symptoms or complications. Frequently recurring attacks of acute bronchitis, chronic bronchitis, a dry hacking cough, a productive cough, bronchiectasis, or bronchial asthma will be present. Of course, a certain number of cases of asthma have an allergic background but not all. Too many cases have been cured by sinus surgery and remained cured to consider all asthmas as being entirely allergic in origin. It is generally agreed that almost all cases of bronchiectasis have an associated chronic sinusitis. It is not generally accepted, but I believe, it is equally true, that all cases of pneumonia either bronchial or lobar, the terminal and postoperative types excepted, have an associated sinusitis. This may be either an acute infection or an acute exacerbation of a chronic infection.

About 10 per cent of patients with chronic sinusitis will have gastro-intestinal symptoms or complications, nausea, vomiting, diarrhea, fever, and pain, either general, or localized in the region of the appendix or gall bladder. These symptoms may be mild or very severe. There may be just a mild nausea without vomiting. Vomiting may be mild, occasional, or constant and pernicious. I have had one death from pernicious vomiting. Autopsy showed no pathology except a very extensive chronic pansinusitis. In several cases the pain was so localized in the lower right quadrant that appendectomy was considered but not done. In all cases of pulmonary and gastro-intestinal symptoms, there must be some mechanism other than the aspiration or swallowing of secretions, as mentioned in most textbooks and periodicals. There are far too many persons, suffering from chronic sinus disease, who aspirate and swallow secretions for years and years and still remain symptomless. Others will develop eye, ear, heart, kidney, cerebral, or joint complications, but remain free from pulmonary or gastro-intestinal symptoms.

Most physiologists tell us that the most accessible place to irritate the vagus nerve is through the nasal mucous membrane. Therefore, a toxic neuritis of the vagus nerve from the infection present in the sinuses seems quite plausible. Selective and specific action of this toxin on the various fibers of the vagus, determine the subsequent chain of symptoms. If the sensory fibers are irritated, pulmonary symptoms will result. If the motor fibers are irritated, gastro-intestinal symptoms will result; and if the sympathetic fibers are irritated, some heart symptoms, such as tachycardia, bradycardia, angina, or pseudo-angina may be the result. The very prompt relief or even complete disappearance of these symptoms after appropriate treatment, together with the fact that this most often occurs long before the nasal discharge ceases during which time the

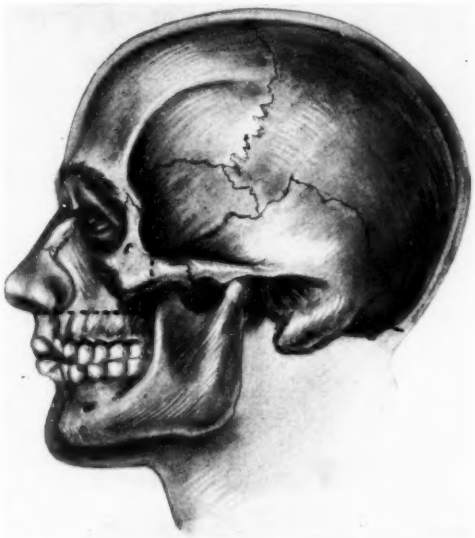

Fig. 1. The site for injection of the sphenopalatine ganglion is marked with an X. It is at the junction of imaginary lines, one running horizontally backward on a level with the tip of the nose, meeting a perpendicular line along the posterior border of the zygoma. A 2 inch needle is used, directed inward, slightly upward and backward.

Fig. 2. Incision for partial resection of the middle turbinate, from above downward along the anterior border. Inset shows, heavily shaded lateral portion, which is to be removed, leaving balance of turbinate and mucous membrane intact.

individual still has ample opportunity to aspirate or swallow secretions, strongly supports this view.

There are undoubtedly a great many other factors, some of which we do not know, that enter into the cause of these conditions. The type, character, and virulence of the attacking organism, the age and resistance of the individual, natural or acquired immunity, inherited tendencies, allergy, and what not, all play some part. Otherwise how can we account for the wide variety of symptoms, or lack of symptoms, and the great variations in the pathology present? Why should one individual have a dry, hacking, or a productive cough, without demonstrable lung pathology, while others have a mild or extensive bronchiectasis or asthma, and still others have gastro-intestinal or cardiac symptoms? With the knowledge that these symptoms and sequelæ do occur in connection with sinusitis, it is my opinion that all cases of frank or obscure pulmonary disease, in which tuberculosis, occupational diseases, and foreign body have been excluded, and many cases of obscure gastro-intestinal diseases, should have a thorough examination of the nose and sinuses, including roentgenograms, to determine the presence or absence of disease therein.

Symptoms other than pain, referable to the eye, are present in about 1 per cent of the cases. These are manifested mostly by disturbances of vision. It may vary from slight blurring or dimness of vision to complete blindness and involve one or both eyes. The pathology present is not constant. It may be a retrobulbar neuritis, an optic neuritis, retinitis, choreoretinitis, iritis, etc. Orbital cellulitis and abscess occur rather infrequently and are due either to erosion through the bone or extension by way of the blood stream.

Symptoms referable to the ear occur in about 2 per cent of the cases. This may be manifested in a number of ways: pain, vertigo, catarrhal or suppurative otitis media, and deafness. The pain or earache may be due to a suppurative otitis media, which will be demonstrated plainly by characteristic changes in the appearance of the tympanic membrane. Many times, however, the patient will complain of severe earache, either in the ear, or

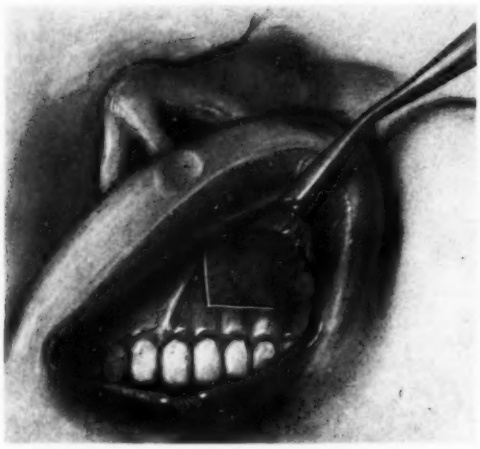

Fig. 3. A right angle incision through mucous membrane and periosteum. Each arm of the incision is between ½ and ¾ inches long.

Fig. 4. Mucoperiosteum retracted upward and outward. Bony wall removed showing thickened, polypoid mucous membrane.

over the mastoid, without any changes noticeable in the drum membrane. This is referred almost always through the sphenopalatine ganglion and can be controlled by cocainization in the ganglion area. The deafness may be the result of an auditory neuritis, otitis, or a combination of the two.

Symptoms due to focal infections such as arthritis, nephritis, pyelitis, peripheral neuritis, etc., occurred in about 2 per cent of the cases in my series. This number I am quite sure is too small, not because sinusitis was overlooked as a cause of focal infections, but because it was not even considered. The teeth, tonsils, prostate, gall bladder, and appendix are frequently examined and eliminated, but the sinuses are forgotten. Much more emphasis should be placed upon the fact that chronic sinusitis can and does cause, any or all, of the diseases known to be or suspected of being due to focal infection. Many times the sinusitis is absolutely silent or asymptomatic and is discovered only after an intensive search for the focus responsible for the patient's general condition. These facts should be remembered so that the sinuses will, at least, be considered, in any search for focal infections.

Symptoms referable to the brain and its coverings occur in a small percentage of cases. Meningitis and brain abscess are due either to direct extension through the bone or by way of the blood or lymph channels. Encephalitis and various mental and nervous diseases are undoubtedly due to toxic absorption.

Fever is a variable symptom. In the acute infections and acute exacerbations of the chronic cases it may be high, depending on the virulence and character of the invading organism, and the disease which it accompanies, such as scarlet fever, influenza, or erysipelas. In chronic sinusitis fever is usually absent, when present, it is usually of the low grade type of evening temperature ranging from 99 to 100 degrees. It may be present for months and is most often suspected of being tuberculous in origin. This is especially true if there is an associated cough. It is frequently aggravated by exercise of a rather mild nature. I have had several patients in whom temperatures would rise to 103 or 104 degrees after a short, brisk walk.

Next in importance is a complete rhinolaryngological examination. Anterior and posterior rhinoscopy, examination of the sinus orifices and nasopharynx with the nasopharyngoscope to determine which sinuses are involved, and the character and amount of secretion escaping therefrom should be performed. Transillumination of the sinuses is very valuable if done in an absolutely dark

Fig. 5. A splendid view of the ethmosphenoid region is obtained by looking through either the nasal speculum or the antral opening in the canine fossa.

Fig. 6. An enlarged, exaggerated view of the ethmoid cells.

room. It will reveal whether or not the disease is bilateral or unilateral, or if one side is more involved than the other. However, it has been my experience that a negative or very clear transillumination does not always rule out sinus disease. If the history and symptoms are strongly suggestive of sinus disease, roentgenograms should be taken. A well made, expertly interpreted roentgenogram is undoubtedly the most important, single diagnostic aid at our command in the study of sinus disease. Certainly every case in which operation is anticipated should have a roentgenogram. In cases where the existing pathology is so evident, that roentgenograms are not a necessary aid in diagnosis, they are absolutely essential as a guide during the operation. In my opinion, doing an operation upon sinuses which have not been made the subject of a careful roentgenographic study is like starting on an automobile or boat trip without a map or compass.

The presence or absence of the frontal sinuses, the relative size and shape of the antræ, the size and extensions, either supra-orbital or infra-orbital of the ethmoid, and the size and extensions of the sphenoids, can be portrayed definitely in most instances. Most of this information can be obtained from a single, anteroposterior roentgenogram made in the Waters position: The patient is placed in a sitting position, using an upright head, Bucky diaphragm tube stand, posterior anterior view, with the chin resting against the plate holder, nose ½ inch away, mouth open 1 inch, focal plate distance 30 inches, central ray perpendicular to the center of the film.

TREATMENT

After the diagnosis is made the problem of treatment arises. As this paper is concerned only with surgical management, other methods of treatment will not be discussed. The age, the physical condition of the patient, the presence of some serious disease such as myocarditis, diabetes, syphilis, tuberculosis, anemia or leukemia, all will have some influence in management. The operation selected should be one that will remove all of the diseased tissue from the sinus or sinuses involved, and leave the nasal cavity anatomically and physiologically normal. The type of surgery necessary in each individual case is often a very delicate problem.

There are too many ill advised attempts to do some type of intranasal surgery for the cure of extensive chronic sinus disease. These are doomed to almost certain failure. The ana-

Fig. 7. Dotted line shows the inverted u-shaped incision in the naso-antral wall. Inset shows flap turned downward into the antrum and the free border of the inferior turbinate.

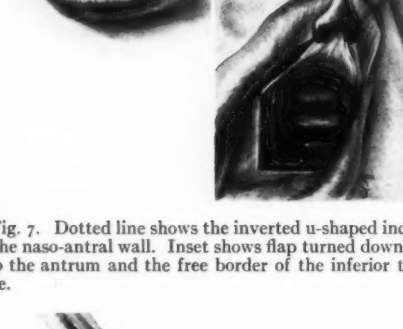

Fig. 8. Sinuses packed with nupercaine gauze. Free anterior end threaded through eye of ring curette.

Fig. 9. Curette removed from antrum by downward and outward pressure on the handle, removing free end of gauze from the sinus through the nostril.

tomical variations in size, shape, and extension make it practically impossible to reach these safely by any intranasal method of approach. The most that can be accomplished is improved drainage. The pathological changes in the mucosa and bone of chronically infected sinuses is of such a nature that simple drainage is not adequate treatment. Intranasal attempts to dilate or enlarge the frontal duct is possibly the most common and most serious mistake of all. It almost always results in a cicatrical stenosis with complete obstruction or obliteration of the duct. Many of the so called radical sinus operations are radical only from the standpoint of normal tissue destruction. All of the turbinates and large amounts of nasal mucosa are removed, apparently without thought or regard to the patient's future welfare. Many operations of the Caldwell-Luc type are called radical. They may be radical but they certainly are not complete.

Chronic frontal sinusitis occurs rather infrequently, or in about 2 per cent of the cases. When it does occur an external operation is

necessary, the type and extent of which will be determined by the existing pathology and the judgment of the operating surgeon. When we have a chronic pansinusitis, a combined external frontal and transantralethmosphenoidectomy is the operation of choice.

The operation which I wish to present is very satisfactory in 95 per cent of the cases requiring surgical treatment. It is a combined intranasal, transantralethmosphenoidectomy. It can be done either under local or general anesthesia. If the disease is bilateral, both sides may be operated upon under the one anesthetic. I usually combine local and general anesthesia. The patient is given a hypodermic of morphine, 1/6 grain, atropine, 1/150 grain, 30 minutes prior to operation. After the patient is completely anesthetized by gas and ether, the mask is removed. A gauze sponge is placed in the nasopharynx to prevent blood and secretions from running into the throat and from being aspirated or swallowed. A Branower breathing tube is placed in the mouth. This tube is very satisfactory in every way. It has fittings for the attachment of sterile rubber tubing on each side out of the way of the operator. Ether vapor is supplied through one side, oxygen through the other. It keeps the tongue out of the pharynx and allows a free exchange of air. The nose and face are thoroughly washed with alcohol (Fig. 1). Then both sphenopalatine ganglia are injected with 2 cubic centimeters of ½ per cent novocain solution, to which has been added one drop of adrenalin, 1:1000, to each dram of novocain. The septal mucous membrane and turbinates are injected with the same solution in exactly the same manner as for local anesthesia. This reduces bleeding to a minimum, prevents or minimizes shock, and helps to control postoperative pain. Both canine fossæ are injected with a small amount of the same solution.

If the nasal septum has not been resected, previously or is deflected, especially in the upper and posterior part where it will interfere with free and easy access to the ethmoid and sphenoid sinuses, it is resected. This procedure may be criticized because of the possibility of infection in the submucous field. Over a period of years and several hundred operations I have never seen any untoward results. On the other hand, where the nasal septum was not resected, it interfered greatly with proper exposure during operation and with postoperative treatments. If the nasal entrance is obstructed or narrowed in any manner, this should be corrected by a plastic operation. Unless the patient has a perfectly functioning nose after operation, the result will not be satisfactory, either to the surgeon or the patient. Ample breathing space is absolutely essential in attaining these results. What is to be gained by doing a beautiful submucous resection, providing ventilation and drainage for the sinuses, and leaving a closed nasal entrance through which the patient can get no air?

The next step is to displace the middle turbinate away from the outer wall. It should never be removed. It is the only protection for the cribiform plate. So long as it is in place, and we stay underneath or external to its upper attachment, there is absolutely no danger of injuring the cribiform plate. If the middle turbinate is enlarged, it can be partially resected (Fig. 2). The ideal way, is to take a sharp knife, split the turbinate from top to bottom and remove as much of the lateral portion as necessary, preserving the medial portion. This preserves all or most of the normal mucous membrane covering the turbinate.

The ethmoid cells are now entered and the anterior wall removed with a small ethmoid rongeur. Using a Mosher curette, more of the anterior cells are broken down. A small strip of gauze, saturated with adrenalin, 1:1000, is placed into the opened ethmoid to remain there until removed through the posterior superior wall of the antrum.

The antrum is opened through the canine fossa (Fig. 3). A right angled incision is used; this provides better exposure with minimum trauma to the tissues. The periosteum is elevated upward and outward and held by a retractor. A small bone drill is used to enter the anterior antral wall, enlarged by a Kerrison rongeur to provide sufficient exposure. The opening in the bony wall should be extended as far forward and downward as possible to obliterate the angle formed by the

anterior and nasal walls (Fig. 4). In extending the opening upward and inward, care should be taken not to injure the infra-orbital nerve. The mucous membrane is now loosened by a small periosteal elevator, beginning at the anterior inferior angle and extending in all directions until the entire mucosa is free. Many times it can be removed *en masse*. More often it is removed piece meal. It is very important that all of the lining membrane be removed. A small laryngeal mirror is used to inspect the outer and upper walls.

The bony, naso-antral wall is removed next by a chisel and rongeur forceps, being very careful to preserve the membranous wall. We now have an unobstructed view of the posterior superior wall of the antrum, which exposes the anterior ethmoid cells. With a small biting forceps or a curette an opening is made into the ethmoid and enlarged with Hajek biting forceps. The gauze strip placed in the ethmoid cells intranasally is removed through the antrum. All of the postantral and infra-orbital ethmoidal cells are exposed and completely exenterated under direct vision (Fig. 5). Next we place a deep, Killian nasal speculum behind the middle turbinate and retract it medially. Using Hajek forceps and Coakley curettes, all of the remaining cells can be removed under the middle turbinate. By looking through the speculum and the antral opening you get an unexcelled exposure of the entire ethmoid labyrinth (Fig. 6). This brings into view the anterior wall of the sphenoid. This may be opened either through the natural osteum or by a small curette. The entire anterior wall is then removed with Hajek forceps. The contents are removed with a small Coakley curette. An inverted u-shaped incision is made in the membranous naso-antral wall and the flap turned down into the antrum (Fig. 7). This prevents subsequent closure of the opening and provides constant drainage at a point near the floor. The sphenoid, ethmoid, and antrum are now converted into one large, smooth cavity, with adequate openings for drainage and treatment, well protected by the middle and inferior turbinates.

A large ring curette is introduced into the antrum under the inferior turbinate and held high against the anterior wall (Fig. 8). Narrow strip gauze, impregnated with nupercaine ointment, is now inserted through the canine fossa, into the sphenoid, then the ethmoid, then the antrum and the end threaded into the ring of the curette, and withdrawn through the naso-antral opening, into the nostril (Fig. 9). Both nostrils are packed with nupercaine gauze. This gauze minimizes the discomfort of the packing, not only while it is in place but also during removal. The incision is closed by two silk or linen sutures. The nasopharyngeal pack is removed and the patient returned to bed.

All packing is removed in 24 hours; irrigations are started after 48 hours, and stitches are removed after 7 days. The average time required for the operation is 2 hours. The average hospitalization is 10 days, and the average duration of treatment is ordinarily 10 weeks.

CONCLUSIONS

Surgery of the sinuses is a major procedure, therefore, thorough examination of the patient is absolutely essential. Complete physical, blood, and urine examinations should be demanded. Cultures of the secretions and pathological examination of the tissue removed from the sinuses at the time of operation should be routine. Minute attention to every detail spells the difference between success and failure, either in the diagnosis or treatment. Nothing should be done hurriedly, neither the history, the examination, nor the operation, because anything that is worth doing, is worth doing well.

INDICATIONS FOR SURGICAL TREATMENT IN SINUSITIS

FREDERICK T. HILL, M.D., D.Sc., F.A.C.S., Waterville, Maine

THE indications for any form of surgical treatment in sinusitis are based upon, first, an accurate diagnosis and, second, a carefully arrived at decision that conservative treatment will either be futile or perhaps uneconomic. It is fundamental that an accurate diagnosis depends upon a comprehensive history and a thorough examination. The possibilities of migraine, allergic conditions, ocular disturbances, intracranial lesions, or general systemic disease must always be kept in mind. The ophthalmologist, the internist, and the laboratory may furnish valuable information which may prevent placing undue emphasis upon some existing abnormality in the sinuses, to the neglect of other possible causes of the patient's condition. Good roentgenograms are indispensable in order to evaluate thoroughly the condition of the sinuses. Occasionally we hear criticisms of an increased tendency to depend upon laboratory aids and consultations for a diagnosis. This may be justified at times, but I cannot subscribe to the all efficient infallibility of any one specialist. Looking into one window does not reveal the condition of the entire house. To the statement that these procedures unduly increase the expense to the patient, let me suggest that this added cost can be absorbed nicely by a similar solicitous attitude on the part of the surgeon in regard to his own fee.

Too often the diagnosis of sinusitis is hastily made upon mere assumption or inaccurate observation. The medical discovery of the paranasal sinuses and the realization of their potentialities in relation to disease, like most geographical discoveries, led inevitably to a period of more or less exploitation. With hasty, inaccurate diagnoses and stereotyped therapy routinely applied, is there any wonder that the effectiveness of treatment for sinusitis has often been viewed with skepticism, both by the practitioner and the layman? This naturally gave rise to a deep-seated prejudice against operations on the sinuses, and we heard the oft-repeated saying, "Once a sinus, always a sinus." Of course, in a strict sense, this is true, as rarely do we obliterate a sinus. The abdominal surgeon removes an infected gall bladder or an appendix; but in operating upon the sinuses we do not remove them. We drain them, break down and remove cell partitions, and remove diseased lining membranes, but we still have the sinuses to deal with after operation. If we have carefully evaluated the condition, studied the clinical pathology, and considered its probable effect upon the patient, we may arrive at a conclusion that some form of surgical treatment to promote drainage or remove hopelessly diseased tissue would prove sufficiently beneficial to the patient to make the procedure worth while. If surgical treatment is decided upon, the particular type of operation should be selected according to the demands of the individual case. We must fit the operation to the patient not the patient to the operation. Under such conditions surgical measures may be distinctly indicated and, if correctly carried out, are usually justified by the results.

Acute sinusitis. In acute sinusitis surgical treatment is rarely called for. Most cases are self-limited and will recover with conservative treatment, while surgical interference may possibly provoke unnecessary complications. An exception to this might be those cases in which continued severe pain, purulent discharge, and the roentgenogram suggest either a delay in resolution or inadequate drainage. In these cases such minor procedures as infracture of the middle turbinate, turbinotomy, opening of the agger nasi cell, or irrigation of the antrum may be helpful. Often the necessity for employing these procedures varies inversely with the thoroughness of early conservative treatment and may be obviated by a stricter regimen of therapy.

Acute sinusitis with complications. In acute sinusitis of the fulminating type, early surgical interference may be necessary. Fortunately, these cases are rare. They are generally seen in younger people and the worst cases follow swimming. There is usually severe pain, tenderness, fever, evidence of sepsis, purulent nasal discharge, and sometimes swelling. In these cases we should endeavor to obtain adequate drainage with a minimum of bone work. Intranasal antrotomy may provide sufficient drainage for the antrum; but with a fulminating infection of the fronto-ethmoidal sinuses, external incision and drainage are preferable. At this stage there should be no attempt to exenterate the ethmoid cells. After the acute condition has subsided, if resolution does

From the Thayer Hospital.

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not take place, an ethmoidectomy, intranasal or external depending upon the conditions, may be performed. Orbital abscess, secondary to ethmoiditis, should be drained externally in a similar fashion.

Perhaps the most serious of these complications is osteomyelitis with its possible sequelæ of brain abscess and meningitis. Fever and pain may or may not be present. There is external swelling, sometimes with a discharging fistula. The one most valuable diagnostic sign, as pointed out by Mosher (4), is edema. It is usually from 7 to 10 days before the infection can be demonstrated by roentgenogram, and the area of involvement will be from 1 to 2 inches beyond what is shown on the film. Mosher (3) has proved the importance of the diploic veins, which run both upwards to the periosteum and inwards to the dura. Retrograde thrombophlebitis of these veins carries the infection upward and accounts for the characteristic pitting edema. The roentgenogram may be of value in early cases by demonstrating the presence of these diploic veins with their potentialities. Early and radical operation is indicated. The skull plate from well beyond the line of edema should be removed and the skin flaps left open for drainage.

Acute exacerbations of chronic sinusitis. Surgical treatment of chronic sinusitis during an acute exacerbation is generally contra-indicated, unless some impending complication makes interference necessary. In such a case one should strive for adequate drainage with such minimum of bone work as is consistent with the condition.

Chronic sinusitis. For practical purposes we may consider 2 forms of chronic sinusitis: the purulent, characterized by a purulent nasal discharge, and the hyperplastic, with polyposis and obstruction. According to Eggston, the former is atrophic, fibrotic, sclerotic, or arteriosclerotic, with an associated condensing osteitis and is due to involvement of the afferent blood vessels; while the latter is characterized by thickened and edematous changes in the mucous membrane, rarefaction and osteoporosis of bone, with inflammatory infiltration of the veins and lymphatics. There may be all gradations of these or a combination of both may occur, even in the same sinus.

Purulent. Many cases of purulent maxillary sinusitis are of dental origin, due to infected molar or premolar teeth. Sometimes this becomes evident only following extraction, when the patient develops a purulent nasal discharge, usually foul in character. If the condition does not resolve after removal of the dental infection and conservative treatment, irrigations of the antrum or a large intranasal antrotomy generally suffices. In some cases there may be sufficient pathology in the floor of the antrum to necessitate operation through the canine fossa. The presence of an alveolar fistula in the site of an extracted tooth is an indication for early surgical interference. Most of these will close following a large intranasal antrotomy, but some will require external operation or plastic closure of fistula. Most cases of dental origin will respond to intranasal drainage.

Many cases of purulent sinusitis may improve with proper attention to associated metabolic or endocrine disturbances. In children, correction of dietary errors and removal of tonsils and adenoids will frequently be followed by resolution. Persistence of discharge, periodic headache, nasal obstruction, laryngeal and pulmonary symptoms, ocular disturbances or evidence of focal infection may indicate the advisability of surgical interference. The position of the antrum, acting as a possible reservoir for pus draining from the ethmoid cells, and the high location of its own ostium make it the least amenable to conservative treatment. Consequently this is the sinus which requires surgery most often. An intranasal antrotomy may cause the infection to subside. If this proves futile, or if there is evidence of marked mucosal pathology, which in all probability would not resolve following simple antrotomy, radical operation, such as the Caldwell-Luc, is indicated. Submucous resection of a thickened, or highly deviated septum, or the removal of the middle turbinate, *in toto* or in part, may improve aeration and drainage of the ethmoid cells. Persistence of suppuration may indicate the advisability of an intranasal ethmoid operation. Generally, this is facilitated by doing a preliminary submucous resection of the septum. As a rule the sphenoidal sinus is included in the operation, as it is usually involved. Less frequently one may see cases of sphenoidal suppuration with postnasal discharge and sometimes ocular symptoms but little evidence of ethmoid involvement. In such cases removal of the anterior wall of the sphenoid may be advisable if irrigations or displacement have proved ineffective. Unless complicated by some such condition as osteoma, mucocele, or involvement of the osseous walls, operation upon the frontal sinus in this type of case is seldom indicated. The frontal sinus is usually afforded adequate drainage by the ethmoid operation, as it has the advantage of gravity. Interference with the nasofrontal duct may be productive of future trouble. Mosher urged "preserving its virginity." Should conditions demand surgical treatment, the external fronto-ethmoidectomy is to be preferred.

Chronic sinusitis — hyperplastic. Perhaps the hyperplastic type of chronic sinusitis is that most frequently encountered. Many of these are allergic. In these, indicated allergic treatment must be carried out. When marked hyperplastic changes in the sinus mucosa are present, this often will not be sufficient. Secondary bacterial involvement seems prone to occur in these cases. Generally a combination of allergic treatment and radical surgery gives the best results. While it is better to avoid surgical measures during acute manifestations of allergy, operative treatment may be decidedly beneficial when these factors are under control.

Unless contra-indicated by such factors as the extremes of age or some associated disease condition the radical type of operation is to be preferred with this form of sinusitis. With marked nasal obstruction, polyposis, and roentgenographic evidence of well established mucosal changes in the antrum, operation by the canine fossa route with removal of the diseased lining would be indicated. This may be combined with the transantral operation on the ethmoids if desired. Any anterior cells which are not accessible may be opened intranasally. If ethmoidectomy is done as a separate operation, I prefer the intranasal procedure, despite the growing popularity of the external operation. In competent hands I think the former is preferable from the patient's viewpoint. Tilley says, "That in seeking to 'make the punishment fit the crime,' with few exceptions the intranasal route should always be chosen in the first instance." Some operators routinely open the sphenoidal sinus in every ethmoid operation, but here again it may be well to individualize. If it does not appear to be infected, it may be left alone at least for the time being. If definitely involved with a polypoid lining, it should be opened as widely as possible. The sphenoidal sinus is often a problem after operation due to tendency to closure from scar tissue. Theoretically the removal of its floor is ideal in order to prevent this closure, but actually this result cannot always be accomplished.

The external fronto-ethmoidectomy should be reserved for those cases which defy simpler methods. Lynch, himself, said, "When all else fails, try this." While the open operation undoubtedly allows a more thorough exenteration than the intranasal ethmoid, the after-results are not always all that one could desire. A completely satisfactory radical operation on the frontal sinus, from the patient's point of view, is something to be desired, but not always attained. Many patients are far happier with a not-quite-so-thorough intranasal ethmoidectomy, even though it may possibly need some revision later. The external fronto-ethmoidectomy should be employed in those cases in which intranasal or transantral operation has failed, when frontal sinus pathology must be removed, not merely drained, or when complications demand an external approach.

The particular type of operation should depend upon the conditions of the individual case. In most cases the Lynch type of operation answers very well and has the advantage of not disturbing the anterior frontal wall. In cases with very large frontal sinuses, however, the Killian operation may be more efficient. Certain cases might justify an obliterating operation, even with the resulting deformity. In the so called conservative operations which open the sinus externally and attempt to enlarge the duct by means of burrs and rasps, it is often difficult to maintain the opening. Therefore, if there is sufficient pathology to warrant external operation, or if the frontal sinus will not resolve after an intranasal ethmoidectomy, the combined external fronto-ethmoid operation seems preferable.

SUMMARY AND CONCLUSIONS

1. The decision that surgical treatment is indicated should be based upon careful, thorough study of the individual case, with consideration of possible associated disease, or environmental factors, and the conclusion that more conservative measures would be futile. The probable effect of the existing pathology upon the patient should be compared to the expected improvement following operation. The simpler procedures, if at all consistent with the clinical picture, are to be preferred. Many times, from the patient's point of view, graded operations and secondary operations are preferable. When radical measures are indicated they should be carried out as thoroughly as is consistent with the safety and future comfort of the patient.

2. Surgical interference is rarely indicated in acute sinusitis.

3. Adequate drainage with a minimum of bone work should be the objective in fulminating sinusitis. Early and radical removal of the skull plate is indicated in osteomyelitis.

4. Most antral cases of dental origin will subside following removal of the dental infection and intranasal antrotomy.

5. In chronic purulent sinusitis underlying factors should be given proper consideration. Intranasal drainage procedures may cause resolution. If unsuccessful, more radical methods may be indicated.

6. In chronic hyperplastic sinusitis the question of allergy must be considered. A combination of allergic treatment and rational surgery often gives the best results. Radical types of operation are usually more effective with this form of sinusitis.

7. The external fronto-ethmoidectomy should be reserved for those cases which defy simpler methods.

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NON-SURGICAL THERAPY IN ACUTE SINUS DISEASE

HENRY BOYLAN ORTON, M.D., F.A.C.S., Newark, New Jersey

IN discussing non-surgical therapy in acute sinus disease, I realize there is nothing original to put forth. The average practitioner looks rather disdainfully on this specialty and is reluctant to refer his patients with sinus disease until some complication has arisen. We often hear patients say that they do not wish any surgery done. Their impression is, "once a sinus, always a sinus, and that usually one operation is but the beginning of many."

There are almost as many ways of treating acute sinus disease as there are men treating it; much confusion has arisen regarding treatment, and it would be futile to attempt to specify any definite method.

Physiology. In the treatment of acute sinusitis, we must not lose sight of the physiological principles which govern the cure of it. Sir St. Clair Thomson, in his observation on the action of cilia, states that the mucous and ciliary action combined, form the first line of defense of the air passages. The arrest of the inspired organisms is due to the secretion of healthy mucus and these organisms are then ejected by the action of the ciliated epithelium. This ciliary action is not influenced by gravity. The sinuses are lined throughout with cilia and their action is always in the direction of the orifice of the opening they are guarding. Slight trauma causes arrest of the cilia. Intranasal temperature has some effect on their movements. In obstructive sinusitis, the cilia are active; pus does not necessarily arrest ciliary action.

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Etiology. Predisposing factors in the causation of sinus disease are many, some of which we might mention here, such as improper hygiene with a general lowering of resistance. Long continuance of untreated allergic conditions predisposes the sufferer to infection by causing poor ventilation and drainage. Then, too, endocrine dysfunction is a factor. The hot, dry air in most buildings during the winter season dries the mucous membranes. The old "swimming hole," nowadays called the pool, where the water is so highly chlorinated that it causes severe irritation to mucous membranes, permits infection to take place readily.

Of the local factors to be considered is edema of the mucous membrane interfering with ventilation and drainage; structural changes in the nostrils, as hypertrophied turbinates or deviated septum; hypertrophied tonsils and adenoids with narrowed nasal openings, anterior and posterior; frequent head colds and tonsillitis; and the acute infectious diseases: as measles, scarlet fever, influenza, etc. These are but a few of the constitutional factors in the etiology of sinus disease.

Symptoms. The symptoms are so well known to all that there is scarcely any need of enumerating them. However, it is when the prodromal symptoms of dryness of the nasopharynx, followed by sneezing, stuffiness of the nostrils, and a general feeling of malaise appear that early treatment is most effectual. This is the time when we may possibly be able to terminate the inflammation by delitescence instead of allowing it to go on to resolution. Suggest to the patient that he rest in bed and he will promptly tell you, "I am not sick enough to go to bed."

Pathology. Inflammation is the succession of changes which occur in living tissue, provided the injury is not of such a degree as to destroy structure and vitality at once. This is naturally accompanied with changes in the vessels and migration of fluids and solids therefrom with changes in the perivascular tissues. Suppuration is always preceded by a catarrhal inflammation.

The usual organisms found are the streptococci, staphylococci, pneumococci, and the various bacilli. A large number of eosinophiles present in the nasal secretion suggest allergy.

In the acute exacerbation of chronic sinus disease, conditions are somewhat different. We have more or less of a permanent pathology, as for instance: deviated septum, hypertrophied turbinates, chronic nasopharyngitis, etc., and here we may have a fulminating type of infection.

Diagnosis. The history is of the utmost significance. Any history of a contagious or allergic disturbance must be taken into consideration. Secretion from the nostrils should be examined for type of organism; and if we find an overabundance of eosinophiles, it is very suggestive of allergy.

Celsus described acute inflammation as redness and heat with swelling and pain; or, as set forth in sinus disease: heat, pain, swelling, disordered function, and possibly discoloration. In general, rest and gentle treatment of the mucous membranes should be prescribed for this acute type and the body should be helped in part to return to normal.

In the diagnosis of acute sinus disease, the methods are well known to all, and there is little need of going into this phase of the subject in detail. To aid in the diagnosis, we have, anterior and posterior rhinoscopy, roentgenography, and the nasopharyngoscope. These are all familiar.

Treatment. To attempt to enumerate the various types of treatment would indeed be a task, for there is no specific cure, either by medicine, surgery, or biology discovered for sinus disease. In the treatment we should (1) help the first line of defense, and (2) combat the infection.

The termination of inflammation may be followed by a return of tissue to health, and this may take place by delitescence or resolution. By dilitescence is meant the abrupt termination at an early stage; resolution is the gradual disappearance of symptoms when the inflammation has passed through its regular stages.

Kyle's dictum years ago, "treat those mucous membranes gently," still holds true and should be adhered to more than it is. In treating the acute sinus infection we must not lose sight of the physiological principles which govern the cure of it. Proetz has found that healthy sphenoids and ethmoids empty themselves completely in 96 hours, frontals a little faster, and the maxillary sinus a trifle slower. It would seem, therefore, that the general principles in the treatment of sinus disease would be proper drainage, aeration, and general support.

Suffice it to say that the treatment of any underlying systemic disease of which the sinusitis is a complication should be carried out. Investigation of the patient as a whole, rather than simply treating the local manifestation, is of the utmost importance. We should look into the bacterial infection, local reactions, allergy, glandular dysfunction, interference with normal ciliary action, nasal obstruction, tonsils and adenoids, the acute infectious fevers, and frequency of colds; and the seasonal nasal allergy and endocrine imbalance must not be overlooked. The otolaryngologist must, therefore, have a good general idea of medicine as well as that of his specialty.

Allergy plays a very important part in the treatment of sinus disease, and often the cooperation of the allergist is of great value to us.

Negus attempts to help the normal defenses by clearing the bacteria from a sinus, for example by lavage, so that they no longer multiply in numbers sufficient to produce lactic acid in harmful concentration, while the diminished alkali reserve in the body can be re-adjusted by the oral administration of alkali. The influence of suitable as well as adequate ventilation should play a major part in the therapy of acute sinus disease.

Fenton states, "Beyond some simple alkalinization there is no decided proof that any special diet will do much for nasal infections." Some authorities state that acids or excess of calcium ions slow, and that alkaline or potassium ions hasten, the rate of action of the cilia.

There has been a mass of research material on the subject of drugs and their action on cilia, and here we might mention a few. Distilled water causes slowing of the cilia. Therefore, we should use some isotonic solution. Drugs which clog up the mucous covering interfere with the cilia; these should be avoided, as for instance, mercurochrome. A 5 per cent solution of cocaine has no paralyzing effect; stronger solutions do. Menthol solutions should not be stronger than 5 per cent.

The vast majority of patients do not care to go to bed upon the first sign of an acute cold but prefer to wait until they are "good and sick."

The following routine of treatment is then established: The patient is put to bed; this diminishes the amount of blood sent to the affected part and lessens the force of circulation. Some form of opiate helps this immeasurably. Ventilation and drainage are accomplished by the use of a cocaine spray or isotonic solution of ephedrine sulphate which is applied locally. Constitutionally, heat, cathartics, diaphoretics, etc., play their part in the successful treatment of acute sinus disease.

Sulfanilamide is a valuable agent in acute streptococcic infections, but it should not be used indiscriminately. Camirol has been used with gratifying results by Coates. These measures may be reinforced with antitoxins and antibodies such as opsonins, phagocytes, bacteriolysins, vitamins, and calcium. Roentgenograms and diathermy have not proved as satisfactory as in other acute infections.

Each individual dealing with acute sinus disease must have a most comprehensive understanding of the whole science of medicine; and when infection does not improve, some surgical procedure may be necessary.

CONCLUSIONS

No specific treatment has yet been found that will cure all sinus diseases.

Prompt, thorough treatment of acute conditions prevents serious complications.

Sulfanilamide in streptococcic infections is a valuable remedy but should not be used indiscriminately.

The co-operation of the allergist is of great value.

THE VOICE AFTER LARYNGOFISSURE AND LARYNGECTOMY FOR CANCER OF THE LARYNX

CHEVALIER L. JACKSON, M.D., M.Sc. (Med.), F.A.C.S., Philadelphia, Pennsylvania

VOICE is the chief consideration in the treatment of most benign laryngeal conditions. In malignant conditions voice must obviously be relegated to second place, because the first and most urgent indication is to cure the cancer (2). It is necessary to explain this to the patient and his family, so that they may readjust their attitude, and accept whatever voice impairment may be entailed in the procedure required to obtain the proper prospect of cure. However, the fact remains that one of the things that the patient is most anxious to know before consenting to the necessary operation, is whether or not he will lose his voice. Many people believe that removal of the vocal cords will make it impossible for them to talk, and the majority of those to whom total laryngectomy is advised are very skeptical when we assure them that they will soon learn a new way of talking after the larynx is removed. We explain that voice is relatively unimportant, as compared with curing the inevitably fatal, if untreated, cancer; but it is very comforting to the patient, conducive to his fit condition for operation, as well as a consolation to his family, to know that he will not be doomed to use the sign language or a pad and pencil the rest of his life to express himself.

It seemed to me that it would be interesting and helpful to conduct a special follow-up on patients who have had the various laryngeal operations done, by sending out questionnaires regarding postoperative voice development. All living patients operated upon since 1929 were sent questionnaires. Replies were received from 51 patients who had had one or both cords removed by laryngofissure and from 30 patients on whom total laryngectomy had been performed.

THE VOICE AFTER LARYNGOFISSURE

Patients who have had one or both true cords removed by laryngofissure practically always develop a useful voice, but its quality, pitch, and carrying power vary greatly. Cicatricial "adventitious" cords develop in most cases, and in patients with good voices, generally either one good cord remains, and a good "adventitious" cord has developed with which it can approximate and vibrate, or two good "adventitious" cords have formed to replace two cords that have been removed. Another mechanism by which a good voice can be produced is ventricular band phonation (1), which is to be regarded as undesirable when it is "usurpative," but which may afford an excellent and very efficient substitute for true cord phonation when 1 or both cords have been removed. One of the factors that is of importance in determining the character of the voice is the degree of motility present, and this in turn generally depends in some measure on how much of the arytenoid was removed and how severe the inflammatory reaction was in the crico-arytenoid joint. The presence of a granuloma may interfere seriously with the production of a good tone, and such tissue should be removed by direct laryngoscopy if it does not shrink up and disappear in a month or two after operation. Sometimes several removals are necessary. In still other cases voice is impaired by the presence of a cicatricial web across the anterior commissure.

Of 51 laryngofissure patients operated upon in the past 10 years, who have answered our questionnaire to date, 43 replied in the affirmative to the question, "Have you developed a useful voice since your operation"? In reply to the question, "Is your voice good, fair or poor," 8 replied "good," 37 "fair," and 6 "poor." A great variety of occupations were represented in the series: physicians, lawyers, bankers, salesmen, teachers, editors, machinists, clerks, electricians, merchants, farmers, business executives, and housewives. Thirty-seven of these patients stated that they had been able to resume the same work that they had done prior to operation. Forty-three were able to use the telephone and 10 stated that they were able to address groups of people, some of them qualifying the statement with the word "small." Sixteen patients could sing before operation, but only 3 claimed they could do any singing since laryngofissure.

We are now at work on a follow-up study of the postoperative appearances in the entire series, with a view to determining, if possible, what ele-

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ments are participating in the voice developed in each particular case.

SPEECH AFTER LARYNGECTOMY

The patient who has had his larynx removed or is about to have it removed is apt to be very depressed at the thought that he may never be able to talk again, but he will be cheered up at once if it is explained to him that the larynx is only one part of the speech mechanism; that it provides a column of air coming up from the lungs and a pair of vibrators or vocal cords, but that it is the "moulds of speech," namely, the tongue, lips, cheeks, palate, etc., which form the words. Then it is explained that it will be necessary for him to learn to collect air in his hypopharynx, esophagus, and stomach to replace the air column from the lungs and to produce tone by means of vicarious cords formed in the hypopharynx or pharynx. He will probably be very skeptical about this but one can assure him that experience has shown us how to help patients get the knack of this sort of speech, and that his course of voice lessons will be begun as soon after the operation as healing permits. Schall (1) has given us 2 excellent papers on this subject and has shown that the laryngectomized patient is "not a social outcast, nor in most cases is he an economic burden." Schall has found that these patients constitute "A most optimistic, cheerful group, neither objects of curiosity nor, in most cases, recipients of charity."

These views regarding the social and economic rehabilitation of the laryngectomized patient are fully supported by the replies to our questionnaire. To date we have had replies from 30 patients operated upon during the 10 year period, and of these 18 replied "Yes" to the question, "Have you learned to speak without your larynx"? Five stated that they could whisper; only 6 said flatly "No." One of the most interesting things noted in the replies to the questionnaires was the fact that in reply to this question, "Is your voice good, fair, or poor"? 50 per cent of the laryngectomy patients replied "good" while only a little over 10 per cent of the laryngofissure patients replied "good"; most of them said "fair." The occupations of the patients who had laryngectomies were as follows: salesmen, merchants, carpenters, army officers, physicians, laborers, steam fitters, molder, housewives, locomotive engineer, wood carver, magistrate, executive, printer, tailor, hotel proprietor, waiter, gate-tender, and milkman. Seventeen of these patients have been able to resume the same work, wholly or partially. Among the questions asked the laryngectomized patients was whether or not they had tried to use an artificial larynx and whether it had proved satisfactory. Only 8 had tried it, and only 2 found it satisfactory; one other said "fairly so" and still another "yes and no."

Morrison deserves a great deal of credit for the work he has done in advocating a definite course of voice instruction for laryngectomized patients. Some will not require lessons, but most will make little progress or develop hopelessly bad habits if they are not systematically taught. We have for the past several years made it our practice to begin voice lessons in each case as soon as the condition of the wound will permit, and we have been obtaining excellent results. We plan now to communicate with all those who have stated in their reply to our questionnaire that they have not been able to develop a satisfactory voice, and to request that they come in for instruction.

It is planned also to examine the entire series of patients with a view to determine what anatomical factors, if any, influence the voice. We have seen in some cases a "pseudoglottis" resembling the true glottis to a remarkable extent; while in others, who have an equally good voice, it is difficult to ascertain what the vibrating structures are. There has been some question as to the advisability of leaving the epiglottis with the idea that it might aid in voice development. Personally, I think this an unwise practice in most cases because of the danger of incompleteness of removal of the tumor. As a matter of fact, I doubt the essential value of the epiglottis as a vibrator, because I have seen equally good voices in patients whose epiglottises have been removed.

With regard to the artificial larynx, I believe it is a mistake to have the patient try it before he has had a chance to develop a bucco-esophageal voice. I believe its use should be reserved for those who are not able, after a fair trial, to develop this more natural "pseudovoice."

CONCLUSION

1. While voice is of secondary importance in procedures undertaken for the eradication of a malignant tumor, the reply to a questionnaire sent out to a series of patients who had had laryngofissure or laryngectomy for cancer of the larynx, showed that the majority had been able to develop useful voices and to resume their original occupation.

2. The majority of the patients who had developed a voice after laryngectomy considered it "good" while the majority of patients who had had laryngofissure considered their voices only "fair."

3. While many patients acquire the knack of bucco-esophageal speech spontaneously, it is best

to give a systematic course of voice lessons to these patients as advocated by Morrison, just as soon as the wound is healed.

4. The artificial larynx should not be tried until after the patient has made some effort to develop a voice without it.

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HOW AND WHEN TO OPERATE UPON THE ETHMOID SINUSES

WILLIAM MITHOEFER, M.D., F.A.C.S., Cincinnati, Ohio

THE ethmoid sinuses play an important rôle in any discussion pertaining to the nasal accessory cavities. The reason for this is quite obvious. Situated as they are between the frontal above and the maxillary sinus below with the sphenoid cavity posteriorly, it can readily be understood how an infection of one of the adjacent sinuses may affect the ethmoid, and also how an involvement within the ethmoid sinus itself may secondarily affect the other cavities. It is, therefore, well to look upon the paranasal sinuses as one system of cavities subject to the same irritation whatever it may be. Good results following nasal sinus surgery will depend largely upon the removal of the vicious circle within the ethmoid, and, in many instances, the careful removal of disease within the ethmoid will be sufficient reason for the abeyance of an inflammation of the larger cavities above and below.

The mucous membrane of the ethmoid sinus is pale, thin, flabby, easily detachable, poorly nourished, and very liable to infection. An inflammatory action, which may be of an evanescent nature in the mucous membrane of the nose, may very readily overpower the vitality of the mucous membrane of the sinuses, especially of the ethmoid. When involvement of the ethmoid sinus takes place, the mucous membrane of the middle meatus, namely, the lateral concave surface of the middle turbinate, the floor of the ethmoid, and the lateral wall of the nose opposite the middle turbinate are first involved. The limitation of the disease to this area probably accounts for the success in treating acute and subacute infections, when cotton tampons saturated with silver preparations are placed in this region.

The predominant types of inflammation are the suppurative, the serous, and the mixed. In the suppurative variety, the mucous membrane is red, evenly swollen, rich in blood, and is firmly attached to the bone because of the presence of connective tissue proliferation. In the serous type, the mucous membrane is pale, edematous, and the poor-in-cells exudate causes connective tissue bundles to spread apart so that the exudate has free play. There is no connective tissue proliferation, except in the late stages of the disease when mixed infection enters the picture.

A patient having a serous catarrh of the ethmoid sinuses is also affected with a catarrhal inflammation of the remainder of the Schneiderian membrane. The inflammation may subside in the nose, but the lateral wall opposite the middle turbinate may remain thickened and edematous; and because of improper ventilation, the inflammation spreads to the ethmoid floor. The presence of edematous thickening of the ethmoid floor is often overlooked, inasmuch as it may be completely covered by a laterally displaced middle turbinate. A latent disease of the ethmoid follows and may remain unrecognized, because of the mild pathological changes which have taken place. It may be well to remember, however, that even in the presence of a mild disease of the ethmoid sinus, very severe symptoms may manifest themselves.

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A point I wish to stress in this connection is that headache, as the result of an ethmoiditis, is not always caused by the ethmoid disease, but may be the result of pressure of the edematous middle turbinate on the lateral wall of the nose, thus irritating the lateral branches of the anterior ethmoid nerve. Infraction of the middle turbinate towards the septum, and the application of trichloracetic acid to the lateral wall of the nose and the floor of the ethmoid are often the only procedures necessary to relieve a patient of headache. The use of trichloracetic acid and infraction of the middle turbinate may be employed with good results in the treatment of chronic ethmoiditis in children.

In making a nasal examination we are apt to pay more attention to the appearance of the hiatus semilunaris, and forget the region of the recessus sphenoethmoidalis. This recess is situated above the superior meatus and forms the interval between the posterior extremity of the supraturbinal and the anterior aspect of the body of the sphenoid. It is a shallow but well defined, triangular fossa of much clinical significance, and is to the posterior group of cells what the hiatus semilunaris is to the anterior group. Inflammation of this recess, especially in subacute infections, may be the forerunner of ethmoid disease, and the inflammatory products from this area may be forced easily into the posterior cells by negative air pressure at the end of inspiration. We may suspect involvement of the sphenoethmoidal recess when the patient continues to complain of stuffiness of the nose and anosmia, following an acute nasal infection, when the nasal examination shows an edematous closure of the olfactory fissure, and when the nasopharyngoscopic examination reveals a mucous plug at the posterior end of the middle turbinate. The recessus sphenoethmoidalis is treated by making repeated applications of a 20 per cent cocaine solution to the edematous olfactory fissure, after which a cotton-wrapped applicator, bent at right angles and saturated with a 20 per cent solution of cocaine is applied to the region of the posterior end of the middle turbinate and then passed upward into the recess. This is followed by an application to the recess of Mandl's solution.

The question of when to operate upon the ethmoid sinuses is readily solved when we are dealing with a patient in whom other sinuses are also involved, especially when there is present an extreme polyposis. The type of inflammation in the various cavities may, however, be different. There may, for instance, be a suppuration within the ethmoid cells with a serous inflammation of the frontal sinus, or there may be a purulent infection in the antrum, while the ethmoid sinuses are involved with a serous type of inflammation. The important point to remember in this connection, is that in doing a radical antrum operation, a careful inspection of the ethmoid sinus should be made and operation proceeded with, if sufficient pathological changes are found in this region. If this is not done, failure may follow the operation, inasmuch as the antrum will act as a reservoir for the infection in the ethmoid cells above. Complications are also more apt to follow the antrum operation, if the diseased ethmoid cells are overlooked. Another cause of failure is the incomplete removal of the ethmoid cells, especially those dipping down into the antrum and those extending laterally along the roof of the orbit. The latter cannot be approached except through the external route, and the former may necessitate an approach through the antrum by way of the canine fossa; although in many instances the downward prolongation of the ethmoid sinuses may be reached if a part of the middle meatal wall of the antrum is removed at the time of doing an intranasal ethmoid operation.

We are prone to think of doing an ethmoid operation in the presence of disease in this area only, but it is my contention based on clinical experience, that quite a few patients with recurrent attacks of headache have an anatomical variation present in the ethmoid region which is the cause. A mild systemic derangement or an allergic reaction may result in edematous swelling of the mucous membrane, thereby closing the nasofrontal duct, and may be the cause of a vacuum headache. Pathological changes, other than the transient edema, are rarely found in these patients, and when continued closure of the nasofrontal duct is present, the headache may be a constant one. I have seen patients who have suffered with headache for 15 or 20 years, who were relieved after the removal of the anatomical obstruction within the ethmoid labyrinth, and in whom, at the time of the ethmoid operation, no gross pathological changes could be found. This experience has convinced me that an investigation of the ethmoid sinuses in an operative exploratory manner is more often indicated, but should be done only after all other means have been tried to relieve the patient.

The anatomical variations are more varied and are greater in number than in any other region of similar size in the body. The pressure of the middle turbinate alone against the lateral wall of the nose, or a high deviation of the septum may be sufficient reason for the presence of a headache.

Other anatomical variations which may be found are as follows: (1) An apposition of the bulla ethmoidalis with the uncinate process; (2) a large bulla or uncinate cell; (3) upward displacement of an infundibular cell into the frontal sinus, thereby closing the nasofrontal duct and preventing the passage of a sound into the frontal sinus; (4) a tortuous nasofrontal duct; and (5) laterally displaced ethmo-orbital cells.

An attempt should always be made to correct the anatomical variation by means of intranasal ethmoid surgery and, if success is not attained, to proceed at a later date by means of the external route. In the majority of instances, the intranasal operation will suffice. We cannot dispute the fact that anatomical variations are frequently observed during the performance of an ethmoid operation for the removal of gross pathological changes. It is questionable, in my mind, whether the headache in these patients was caused by the anatomical variation or by the disease within the sinus.

It is often very difficult to decide whether the ethmoid sinus alone is affected, or whether or not other sinuses are also involved, and, if so, whether the ethmoid disease is the cause of the infection in adjacent cavities. The various diagnostic means at our command, plus careful and repeated examinations, will help to solve the problem. Chronic purulent ethmoiditis is rarely satisfactorily treated in a conservative manner. Surgery is usually necessary. The serous type, based on an allergic background, is often amenable to treatment without surgery. If satisfactory results do not follow desensitization treatment, surgical intervention is indicated, and should not be postponed too long, for the reason that there are many allergic individuals who require operative interference before a satisfactory result is obtained.

I firmly believe that the intranasal ethmoid operation does not receive the attention it deserves by most rhinologists. Septum operations are done with the hope that the mere removal of the nasal obstruction will be sufficient to care for a chronic ethmoiditis. That this does happen occasionally will not be denied; but that it often fails to produce the desired result must also be admitted. I have seen innumerable patients who had a septum operation performed elsewhere, and who were not relieved of their symptoms until an intranasal ethmoid operation was done. It is, in my opinion, good surgical judgment at least to infract the middle turbinate at the time of doing a septum operation, and if pathological changes are seen on the ethmoid floor, to proceed with the ethmoid operation intranasally. To do this, and at the same time preserve the middle turbinate, is, in my opinion, a conservative operation. An intranasal ethmoid operation should never be done during the period of an acute involvement, especially if a Streptococcus hemolyticus infection is present. If an operation is indicated at this time, because of severe symptoms or an intra-ocular or meningeal complication, it must be done extranasally. The removal of a part or the whole of the middle turbinate, during the stage of an acute infection, is dangerous. The division of the olfactory sheath, when this is done, allows for direct pathway of the infection to the brain. If sufficient drainage cannot be established because of a deviated septum, one should not hesitate to correct the septal deformity and infract the middle turbinate after all measures have been tried to relieve the patient.

Following an ethmoid operation, we may occasionally see an acute flare-up of a latent antrum infection, inasmuch as an ethmoiditis may often be associated with slight changes in the antrum, which do not become manifest until after operation on the ethmoid. I have seen this happen less frequently if part of the middle meatal wall of the antrum is removed at the time of doing an intranasal ethmoid operation. When this is done, there is less likelihood of edema of the lateral wall of the nose causing closure of the ostium, with retention of secretions within the antrum cavity. Furthermore, should an acute exacerbation of a dormant antrum disease occur, irrigation is easily done through the wide, middle, meatal opening. Another good reason for removing a part of the middle, meatal wall is that thus one can reach the downward displaced inferior hiatus cells.

There seems to be a difference of opinion among rhinologists as to the removal of the middle turbinate. In my estimation, it should be preserved, if possible, its removal should depend on the width of the nose, on its size, and on the pathological changes which may have affected it. If there is much hypertrophy, or if polypi are confined to the concave side of the middle turbinate, a part may be removed on its lateral aspect. When the middle turbinate cannot be made to occupy a medial position after infraction, a small incision made high up into the lateral attachment will tend to keep it in good position.

OPERATIVE PROCEDURE

At the first step of the intranasal operation, the uncinate process is removed with knife or punch forceps. If difficulty is experienced in passing a sound into the nasofrontal duct, the cells lying anterior to the duct are curetted or removed with a forceps. After the bulla ethmoidalis is opened,

the remaining ethmoid cells are removed with an upward biting forceps, which is of such small size that it can be used also to probe the various cells, as one proceeds with their removal. This small forceps is very satisfactory and safe, so that in many instances the entire intranasal operation can be done without using any other instrument.

We are probably agreed that very seldom can a complete ethmoid operation be done intranasally, chiefly because of the lateral and upward prolongations of the cells. This does not mean that one should desist in operating intranasally, inasmuch as drainage and ventilation with patency of the nasofrontal duct following operation may relieve the patient. It is true there may still be present a slight nasal discharge but this is of little inconvenience to the patient, if the headache from which he has suffered for many years has disappeared. If the skiagram shows the presence of laterally displaced ethmoid cells, the patient should be told that if intranasal measures fail to relieve the headache, an external surgical approach may be necessary. When the skiagram shows no orbital prolongation of the ethmoid sinus, we may expect better results following the endonasal measure. One thing must always be borne in mind, namely, that good results are not obtained immediately following the operation. Granulation tissue and edematous mucous membrane in the region of the operation must be cared for, either by applying a 5 to 10 per cent solution of nitrate of silver, or by removing the offending tissue with a punch forceps. We must also remember that the nasal mucous membrane has been involved in the process, and some time is required to establish a normally functioning membrane after the irritant has been removed. As has been well said, "A chronic disease requires a chronic remedy." The middle turbinate must remain in midline, and postoperative displacement may be found necessary.

The external ethmoid operation, in my opinion, is indicated only after the intranasal procedure has failed to relieve the patient; the exception is an intra-orbital or meningeal complication. Severe symptoms manifesting themselves during an acute exacerbation of a chronic ethmoiditis may also require extranasal surgery. The appearance of much pus coming from the nasofrontal duct during an intranasal ethmoid operation may require an immediate external operation.

Space will not permit a detailed description of the external ethmoid operation. The pertinent facts which I wish to bring to your attention are the following:

1. The operation is done with a local anesthetic, unless edema of the parts prevents its use.

2. Before making the external incision, a mucous membrane flap of the lateral wall of the nose is made. This flap is dissected downward, with its base lying over the upper edge of the inferior turbinate. After the operation is completed the flap is placed upward and covers the remaining portion of ascending process of superior maxilla.

3. After the ethmoid cells have been taken care of, the greater portion of the ascending process of the superior maxilla is removed. This, I consider an important part of the technique, as it usually insures patency of the nasofrontal duct.

4. The posterior portion of the lamina papyracea is preserved, if possible, so that prolapse of the orbital tissue does not follow.

5. A large part of the nasal bone is removed.

6. The mucous membrane of the posterior wall of the nasofrontal duct is left untouched, unless gross pathological changes are present there.

7. The processus frontalis is carefully reduced in size with a flat chisel until it is on a level with the medial wall.

8. If the mucous membrane of the anterior inner wall of the frontal sinus is not too thick, a flap is made with the base of the flap medially placed so that it may be carried downward over the remaining portion of the processus frontalis.

Complete exenteration of the ethmoid cells is important. The posterior, laterally displaced ethmoid sinuses, which are the most difficult to reach, are cared for with small, curved curettes. If the mucous membrane of the sphenoid has undergone hyperplastic changes, it is dislodged with small, curved elevators. In some cases, we have been able to preserve the middle turbinate. A balloon tube is placed in the region of the newly formed nasofrontal duct and is allowed to remain for 3 days. There is less danger of the flaps being disturbed when this form of dressing is used.

CONCLUSIONS

One of the important problems confronting the rhinologist is the proper surgical approach to the nasal accessory sinuses. In many instances, the key to the situation lies in the ethmoid sinus. A careful study of this region will uncover many times an unsuspected latent disease. A carefully done intranasal ethmoidectomy is more often indicated and should be the operation of choice, especially when a mild pathological change in the ethmoid sinus is present which eventually, if left undisturbed, will produce changes in adjacent cavities. To give the ethmoid sinuses the attention they deserve will be the means of procuring better results and of preventing nasal sinus surgery from falling into disrepute.

SYMPOSIUM: CANCER

SURGICAL TREATMENT OF CANCER OF THE TONGUE

LELAND R. COWAN, M.D., F.A.C.S., Salt Lake City, Utah

BEFORE the advent of irradiation therapy, surgery was the sole accepted method of treating cancer of the tongue. This consisted of various forms of cauterization, the removal by the scalpel of the primary lesion as a partial, hemi, or total glossectomy, and in addition any structures invaded by cancer adjacent to the tongue.

In many surgical clinics some type of neck dissection also was done. This varied from a simple excision of one or more groups of neck nodes, on one or both sides of the neck, to a complete dissection *en masse* of nodes in one or both sides. These procedures were usually the ones followed whether nodes were present or absent, and whether in an operable or advanced stage of the disease. The methods varied but little, except as to certain technical surgical points, such as whether the procedure was carried out in one or in several stages, and whether the primary lesion was removed before or after neck dissection.

With the introduction of irradiation therapy, a better understanding of the peculiarities of the disease, the histological grading of tumors, and studies into radiosensitivity and radioresistance, treatment procedure has become considerably modified and in many instances has been completely changed.

The trend in the main has been for more conservative surgery; and yet at the same time in some clinics the opinion still prevails that surgery is the method of choice in all except a minor selected group and in the hopeless cases. Opposed to these are those who believe that irradiation is the major method of treatment, and that surgery is a mere adjunct or accessory factor.

A survey of the literature shows no uniformity of opinion, and statistics are most confusing and in many places are very misleading in their deductions.

It is fair to say, however, that surgery and irradiation have now proved such complementary agents, that in the great majority of cases the one is very dependent upon the other for the most efficient care and to assure the most comfort to the patient. Both the ambitious surgeon and the radiotherapist still overestimate their own fields too often at the expense of the other. No one can denounce the results of irradiation or of surgery; but in a disease with so many varied clinical and pathological aspects, it appears that neither field occupies priority over the other.

With due respect to the trained surgeon and to the radiotherapist, this paper will deal primarily with the surgical aspects of the disease, but certain radiological points will have to be brought into the picture. Factors that seem important in the decision for surgical intervention, as gleaned from clinics where larger groups of cases have been studied, and also from the personal experiences of the author, will be presented.

A consideration of the treatment of lingual cancer involves 2 major problems: (1) that of the treatment of the primary lesion, and (2) that of the treatment of the associated paths of extension of the disease.

PRIMARY LINGUAL CANCER

In regard to primary lingual cancer, we have 2 points to consider: (1) how the disease can be prevented; and (2) the method of treatment to be employed when once the disease is present.

Prevention of the disease. It is estimated by various authors (3) that about 50 to 75 per cent of lingual growths can be prevented by care of precancerous lesions; and that leucoplacia alone accounts for about 35 per cent of all buccal cancers. Under such circumstances, all precancerous lesions, as leucoplacia, fissures, ulcers, warts, or questionable local inflammatory processes should be looked upon as probable inevitable cancers and should be removed.

Removal is best accomplished, and at the greater comfort and safety of the patient, by some type of surgical procedure in preference to the use of radium. This may be by excision with the scalpel, electrosurgical excision, or desiccation.

It is dangerous to temporize with the continued application of caustics in questionable lesions, and

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such procedure is to be condemned. All questionable cancers should be looked upon as actual cancers until proved by biopsy specimen, and should be removed widely, *en masse*, wherever possible. Bloodgood states as follows: "Whenever it is possible to completely remove the local lesion without mutilation of tissue, there is every advantage in having the biopsy specimen consist of the entire lesion."

Treatment of primary lingual cancer. When it is fully established that lingual cancer has developed, it becomes a problem for individual appraisal for treatment on its own merits. No routine procedure can be applied to all cases. Each case is one for individual study and individual care. Inadequate study, procrastination, and failure of adequate removal when once it has been fully established that cancer is present convert many into failures that would otherwise be successes. Failure and success are usually in proportion to adequate and inadequate initial therapeutic procedure.

A study of the literature on lingual cancer presents many interesting facts that should form some basis upon which to consider treatment in most cases. It is admitted that no hard and fast rules can be laid down. Therapy is changing and advancing, and this is especially true in the field of irradiation.

Anatomy of the tongue. To begin with an anatomical study of the tongue is important. From Ewing's writings we find that the surface epithelium of the tongue is quite varied in different locations and under different pathological conditions. Normally, the upper surface and the tip of the tongue is covered with adult squamous epithelium which, when cancer develops, tends to produce spine cells, pearls, and keratin, with all the characteristics of adult squamous carcinoma. The lateral border or sides of the tongue are covered with a more modified transitional epithelium in the main. The posterior surface of the tongue is very irregular, with adult and transitional epithelium, mucous glands, and a liberal mixture of lymphoid tissue and lympho-epithelium; the latter extend at times somewhat along the lateral surface of the tongue.

Lingual cancers arising in these various types of epithelium often act quite differently in their growth capacities locally, in their slowness or rapidity of dissemination, and in their response to both surgical and irradiation methods of treatment.

It is interesting to note that in the pathological tongue, as in luetic glossitis, these differences in behavior may be exaggerated.

Gradation of tumors. There are those who believe that gradation of tumors in tongue cancer is of no prognostic significance. R. Phillips, from a report on tongue cancer, from St. Bartholomew's Hospital, states: "The percentage of cures of tumors of Grades 1 and 2 was more than double that of tumors of Grades 3 and 4 whether the treatment was by surgery or radium."

It must be kept in mind that no two pathologists grade tumors quite alike and, therefore, there is bound to be some difference of opinion and deduction in such work.

From the standpoint of gradation of tumors, we find A. S. Morrow's cases: Grade 1, 54 per cent; Grade 2, 41 per cent; Grade 3, 4 per cent; and Grade 4, 0.

Hayes E. Martin's cases show approximately: Grade 1, 15.9 per cent; Grade 2, 55 per cent; and Grade 3, .7 per cent.

James J. Duffy's 252 cases of lateral border of the tongue cancer, show: Grade 1, 21 per cent; Grade 2, 76 per cent; and Grade 3, 3 per cent.

Duffy, in a series of all locations of tongue cancer, shows about comparable percentages of Grade 1 and Grade 2, with his lateral border group.

These citations show a large percentage of tongue cancer to be either Grade 1 or Grade 2. They are usually looked upon as the more favorable groups for surgical removal, in that it is expected they are radioresistant, growth is slower, and metastases occur less often.

Quick states, however:

> "Radiosensitivity and grading are not exactly parallel. Grade 2 or even Grade 1 epidermoid carcinomata may be relatively radiosensitive by reason of their vascular apparatus even though the tumor cells are fully differentiated, or nearly so. An infected anaplastic tumor may be more radioresistant than a surgical clean Grade 1 growth. A fully differentiated growth in an otherwise normal tongue varies considerably in radiosensitivity from another fully differentiated growth in a luetic tongue by reason of the fibrosis and altered capillary blood supply, the result of the luetic glossitis."

Even though most cases do fall into Grades 1 and 2, the most favorable groups surgically, on further analysis one would be led to believe they are not as favorable surgically as on first thought.

Raven states that node involvement in tongue cancer occurs in 69 per cent of the cases before 6 months, 42 per cent before 3 months, and 27 per cent before 2 months.

From A. S. Morrow's group of 98 cases, 60 per cent of the patients applied for treatment who had had the lesion less than 6 months. Approximately, 60 per cent showed nodes present, 38 per cent of which were bilateral. Of 80 patients operated

upon in whom nodes were present, about 50 per cent showed metastasis. From this it would appear that about 50 per cent were inflammatory nodes only. In other words, about 30 per cent of the patients were admitted with metastasis, 20 per cent of which were bilateral. Ninety-five per cent of the cases were Grades 1 and 2.

Out of Martin's 322 cases of tongue cancer, 113 patients showed metastasis on admission, or about 35 per cent. Of these 322 cases, approximately 70 per cent were in Grades 1 and 2.

Duffy reports approximately 30 per cent of his patients showed metastasis on admission, approximately 20 per cent of which were bilateral, and 80 per cent of his series were Grades 1 and 2.

From these above findings, therefore, about one-third of the cases are advanced, or fairly so, on admission from the standpoint of metastasis alone; and about 80 per cent, more or less, are Grades 1 and 2 according to Morrow, Martin and Duffy.

Undoubtedly, a fairly large percentage of lingual cancer when first seen is either spread beyond the tongue, beyond the midline of the tongue, or shows metastasis, or in other words, is in an advanced stage of the disease. Morrow states that two-thirds of his surgical group were advanced in the sense of having spread beyond the tongue or to the cervical lymph nodes.

Roux-Berger, from statistics of the Curie Institute in a study of 386 cases of tongue cancer, found that 204 cases, or 58 per cent, were advanced in the sense that the lesions involved more than one-half the tongue, floor of the mouth, the whole tongue, or extended to neighboring tissues.

W. Baensch states, in his series of 55 cases, that 90 per cent were inoperable.

N. Petroff, in a series of 341 patients who applied for treatment, found 149 incurable and not suitable for treatment.

It is estimated by Duffy, in his series of 252 cases of cancer of the lateral border of the tongue, that in the more advanced group 20 per cent had spread beyond the midline, usually with extensive unilateral or bilateral metastasis.

From these reports it would appear that lingual cancer, irrespective of the grade, is advanced locally and metastasizes early and quite widely in a fairly high percentage of cases when first seen.

Location of lingual cancer. A. S. Morrow, in a series of 92 cases, reports the location of lingual cancer as: tip, 4.3 per cent; margin, anterior two-thirds, 43 per cent; margin, posterior one-third, 16.3 per cent; dorsum, 14.1 per cent; base, 5.4 per cent; undersurface, 10.8 per cent; and whole tongue, 5.4 per cent.

W. Baensch, in a series of 55 cases, reports the following: anterior portion, 50 per cent; base, 32 per cent; and lower surface, 18 per cent.

Hayes E. Martin, in a series of 322 cases, reports the location of lingual cancer as: anterior third, approximately 14.6 per cent; middle third, approximately 56 per cent; and posterior third, approximately 29.5 per cent.

The foregoing locations of cancer of the tongue furnished by these authors compare quite favorably as to the most frequent sites of the disease. Location alone, is a real factor from treatment standpoint without regard to size or gradation of tumors, accompanying infection, age and general condition of the patient, or the question of metastasis. It seems from the locations given that a fairly large percentage of tongue cancers are not the most accessible surgically. Accessibility, ease and safety of removal with adequate sacrifice of tissue which is so necessary for curability, are the most essential factors here as in all surgical cancer procedures.

Size of the lesion, or extent of the disease, undoubtedly, is of great importance in deciding the type of therapy. Surgical removal of cancer in an organ so important and so anatomically placed as is the tongue, with its surrounding adjacent vital structures, the difficulty of accessibility in the greater part, without extensive mutilation, is one for the most careful and thoughtful consideration.

Roux-Berger, from the Curie Institute, reports in 198 cases of cancer of the dorsum of the anterior two-thirds of the tongue, that the lesions were advanced in 70 cases, or 35 per cent, in the sense of the disease involving more than one-half of the tongue, extending to the floor of the mouth, or extending to contiguous structures. In 91 cases of cancer of the base of the tongue, the lesions were advanced in 68 cases, or 74.5 per cent, in the same sense of extent of involvement. In 93 cases of the undersurface of the tongue, the lesions were advanced in 66 cases, or 70 per cent, in the same sense of extent of advancement of the disease. It is interesting to note that from Moure of the Curie Institute, in an analysis of 42 cases of cancer of the tongue treated surgically alone, 13 cases or 31 per cent were lesions more than 2 centimeters in diameter but limited to one-half of the tongue; and that 8 cases or 19 per cent were lesions involving more than one-half of the tongue or floor of the mouth. Of these 21 cases, all but one showed postoperative recurrences, and there was only one 5 year cure in the 21 cases.

Most lingual cancer occurs in the advanced years of life. From various clinics the average would be about 60 years of age, the time of life

when cardiovascular and renal diseases are most common.

From these reports it would seem that major surgical procedures, the extent of which is necessary in tongue cancer, might be challenged in most instances in view of the not uncommon inaccessible locations, advancement of the disease, cosmetic and functional results, the usual presence of infection, shock, the not uncommon occurrence of respiratory and cardiovascular complications, and the high primary operative mortality which is 9 to 20 per cent. When one considers the low percentage of cures or 5 year end-results and postoperative recurrences, surgery might be further challenged. It is reported by some that surgical recurrences are as high as 59 per cent. Roux-Berger, in a series of 198 cancer cases of the dorsal anterior two-thirds of the tongue, found 23 per cent of the cases to be postoperative recurrences. Therefore, in looking at the primary lesion from many standpoints and from the evidence that one finds in the literature, it seems that surgery alone might occupy a limited place for the care of the primary lesion; and when viewed in the light of irradiation literature, it would seem to occupy a still more limited place. Undoubtedly, small lingual cancers of the tip of the tongue, the dorsum in its anterior half and anterior lateral margins, where accessibility is easy and wide and complete removal can be accomplished, are followed by a sufficiently high percentage of curability to warrant the use of surgery in the trained surgeon's hands. But even here, before surgery is elected, there should be reasonable hope of curability of both the primary lesion and the metastases that might be present. Even here surgery might be challenged by the radiotherapist as being no more efficient. It is questionable whether surgery alone in other lingual cancers is justifiable.

Surgical procedure in lingual cancer. When surgery is elected, the scalpel and the endotherm knife seem to be the method of choice. Plastic repair is accomplished easily with either. The endotherm knife offers the advantage of a dry field with minimal destruction of tissue, and lymphatics are probably sealed by this procedure.

Wide, mutilating operations in those cases beyond the borderline or question of operability are just as futile as the same group treated with large doses of irradiation. The intractable pain without cure of the disease in but rare instances, and general discomfort and disfigurement of the patient, would justify the statement often made that the treatment is worse than the disease. It is still a wise providence to appreciate the limitations of any form of therapy in the cancer patient. It would appear that surgery occupies a more reserved place than formerly, but an indispensable place.

Surgery and irradiation undoubtedly are dependent upon each other for the best results in the greater number of cases, and both have a definite place in the treatment of the primary lesion. The one is complementary to the other; they are best when used singly at times, and again prove advantageous when used in combination with each other.

By removing the main part of the mass surgically in the case of large bulky lesions in the posterior portions of the tongue, greater access to the base of the tongue is facilitated for irradiation, and a better opportunity for cleansing purposes is at hand, which is so essential to successful treatment.

Local removal of bulky, recently treated lesions with radium needles or radon to avoid marked local necrosis and infection, is quite necessary in a fair percentage of cases. Excision of areas of recently radiated tissue in the presence of luetic glossitis, is most important. These patients are known to tolerate radium less efficiently and are subject to early necrosis and subsequent infection because of their altered blood supply and increased fibrosis.

Excision of areas of late radiation fibrosis followed by necrosis, questionable areas of disease in late, fully radiated tissue, or the group of hopeless radioresistant cases, as established by a full therapeutic dose of radium, all call for some surgical procedure in their time and place. This is usually best accomplished with the endotherm knife or actual cautery, and is best left wide open for cleansing purposes and as an aid for detecting suspicious recurrences. Usually hemorrhage is easily controlled and, when the surgical procedure requires hemiglossectomy, ligation of the lingual artery usually can be done under vision without much difficulty.

Exposure of the external carotid artery, with ligation of the lingual branch, or the external carotid itself to control hemorrhage before or after radiation, is often a necessary procedure and a life-saving measure.

It is a hopeless and futile surgical attempt to remove any of the anaplastic group, in the light of present-day irradiation methods. These growths are known to be aggressive locally and disseminate early and widely in most cases.

From St. Bartholomew's Hospital we find in Grade 3 and Grade 4 cases that the results of surgical and irradiation procedures produce about the same percentage of cures. It would seem, if

this be true, that surgery would be the more radical approach and therefore not indicated in these Groups.

METASTATIC LINGUAL CANCER

Indications for operative intervention in metastatic lingual cancer are dependent upon many factors and, just as in the primary lesion, each case is one for the most thoughtful and careful appraisal as an individual problem.

Primary and metastatic diseases are always dependent upon each other for the extent and type of therapy indicated. Some advise routine neck dissection in the presence and in the absence of nodes, in an operable and inoperable stage of the disease; others irradiate practically all metastases in all stages and types of the disease, and still others advise a combination of conservative surgery and irradiation therapy.

The tongue is a good example in the group of intra-oral carcinomas in which no one can predict with any degree of certainty which nodes are most likely to be involved should metastasis take place, and thus be able to suggest a standardized method of routine treatment.

Contralateral, bilateral, odd-position, and distant metastases are known to occur sufficiently frequently that one must be on the alert for any possibility in tongue cancer.

Duffy's report on the location of metastases in tongue cancer is shown in Table I.

TABLE I.—LOCATION OF METASTASES IN TONGUE CANCER

	Submaxillary nodes per cent	Upper deep cervical per cent	Carotid nodes per cent	Bilateral per cent
Tip	31.6	5.3	26.4	20.9
Dorsum	6.8	59.6	13.5	20.1
Lateral border	31.5	20.0	37.1	11.4
Base	1.3	53.0	24.7	21.0

Cure reports. Gordon B. New, of The Mayo Clinic, reports out of 156 traced cases of operations on cancer of the tongue, that 5 year cures were obtained in 29, or 50 per cent of 58 cases in which nodes were not involved but dissected; 19, or 52.8 per cent of 36 cases in which nodes were not involved clinically and were not dissected; 8, or 14.3 per cent of 56 cases in which nodes were involved and were dissected. For the group, 58, or 37.2 per cent were living 5 years or more after operation.

A. S. Morrow reports 5 year survivals as follows: all cases, nodes not involved, 32.4 per cent; all cases, nodes involved, 11.5 per cent; the group, for all cases treated by surgery, 20 per cent.

Morrow further states that the percentage of 5 year cures from bilateral dissection is more than double that obtained by unilateral operations; and results in which unilateral or bilateral node dissection was supplemented by a supraclavicular node operation were still better, namely, 50 per cent 5 year survivals.

Hayes E. Martin, from a series of followed 5 year results of 290 lingual cancer cases, including a consecutive series of all cases, early, operable, inoperable, and advanced, reports: 5 year survivals, all cases, 26 per cent; no metastases at any time, 5 year cures, 40 per cent; metastasis present on admission, 5 year cures, 5 per cent; and metastasis developed after admission, 5 year cures, 22 per cent.

This seems to include surgical and radiological methods singly or combined. It is interesting to note the high difference in curability rate between the cases that were admitted with metastasis and those that developed metastasis after admission.

One can hardly compare the results of these various authors and draw any definite conclusions, because there is no uniformity in the selection or makeup of the material, or the exact type of procedure done. Each author has his own idea of what are operable, favorable, inoperable, or advanced cases.

Martin's idea is worth consideration. He advocates the need for a uniform, tabular method for reporting end-results. This he believes would overcome the many objections to the arbitrary selection of early operable or favorable cases upon which reports of cure-rate statistics are often calculated. Further that these calculations should be made rather upon consecutive material of all patients in all stages of the disease, both early and favorable, and those hopelessly advanced over a sufficiently short period during which treatment methods would not have changed materially.

Despite the fact that there is no uniform method of gathering statistical data at the present time, and that it is difficult to draw any exact and definite conclusions, the literature contains pertinent facts that are worth consideration when the question of operative intervention in lingual cancer metastasis occurs.

Duffy reports cervical lymph node metastases from 252 consecutive cases of carcinoma of the lateral border of the tongue, as follows: (1) No metastasis occurred in 103 of the 252 cases at any time. This would be 40.8 per cent of the cases that never developed metastasis in lingual cancer over the period studied. (2) From a series of 268 cases of all tongue cancer, 43.3 per cent never developed metastasis over the period studied.

(3) The percentage of cases with no nodes on admission and which did not have nodes throughout was 60.3 per cent.

Hayes E. Martin, in a 5 year study of 322 cases of tongue cancer reports: (1) One hundred twenty-five cases or approximately 40 per cent showed no metastasis at any time. (2) Metastasis present on admission was found in 113 cases, or approximately 35 per cent. (3) Metastasis developed after admission in 84 cases, or approximately 26 per cent.

It is, however, interesting and fair to note that N. Petroff, from the Institute of Oncology of Leningrad, shows in a series of 192 of 341 patients who were acceptable for treatment, 20 per cent with no palpable nodes, 47 per cent with nodes that were palpable or movable, 33 per cent with nodes that were palpable or fixed, or a total of 80 per cent with nodes present. However, this essay shows "no pathological reports." I am, therefore, wondering whether the presence of palpable nodes or metastases here means those microscopically proved, or whether a large percentage of these might not be simply inflammatory nodes. If so, the findings might in the latter event be quite comparable to the findings of other authors in view of the fact that Morrow found that about 50 per cent of palpable nodes showed only microscopically proved disease. Duffy, Martin, and Morrow are quite in agreement with each other in such findings as to the percentage of cases with metastases.

The foregoing statistics are interesting in view of the surgical viewpoint so prevalent, that a unilateral or bilateral block dissection of nodes of the neck or some modified neck dissection, whether nodes are present or not, is indicated almost as a routine procedure in the favorable or operable cases in many surgical clinics. Their argument, in part, in favor of this is substantiated by the fact that a fair percentage of cases without palpable nodes on microscopic examination shows cancer to be present. A. S. Morrow reports that in over one-third of his cases in which nodes were not palpable, microscopic analysis revealed the presence of cancer. Also, it is argued that 5 year surgical cures are over twice as high in patients without metastatic nodes, as in those with metastatic node involvement. This naturally would be expected. But how much did the surgical procedure actually contribute to this increased percentage of cure in the cases of those operated upon without metastasis in the lymph nodes? Would these results and percentages not have been virtually the same without surgical removal of those lymph nodes?

From Gordon B. New's statistics, in cases in which no nodes were involved, it appears that approximately the same number of 5 year cures, or 50 per cent, are obtained whether neck dissection was done or was not done.

All this data would lead one to believe that more block dissections or neck dissections of modified type are done than is absolutely necessary in this disease. The objection might be raised, however, that even though many neck dissections are done in cases where metastasis never develops, routine neck dissection should be done because it would be a life-saving measure in those who would develop metastasis had it not been done. This would be in that group of cases in which about 26 per cent, according to Martin's statistics of 290 cases, developed metastasis after admission. In this group, Martin had a 22 per cent 5 year cure, which seems very favorable from the standpoint of metastasis. If we had any definite proof that routine neck dissection in this group would accomplish more than waiting to care for metastases after they develop, routine neck dissection might be accepted without question. However, we have no assurance that should neck dissection be done, metastasis might not occur in the operative field of the same side, beyond the operative field, in the opposite side of the neck, or distantly, as occasionally occurs.

According to Morrow in over 10 per cent of patients in whom hyperplastic nodes have been removed by upper node dissection, metastasis developed outside the operative field in the same side, in the supraclavicular region, or in the opposite side of the neck at a later period. I assume this deduction might be an argument for a complete bilateral block dissection *en masse*, to prevent such happening. This argument would seem an excellent one for a thorough and complete type of block dissection being advised in the presence of metastatic operable disease, but it seems that other factors might be an objection to such a routine procedure. We have no assurance that the most complete block dissection for either hyperplastic or metastatic node involvement will eliminate the possibility of disease from occurring in or beyond the operative field.

The primary lesion might still be uncontrolled or might be the seat of probable recurrence at least in a fair percentage of these cases. Duffy states that the primary disease was uncontrolled in 37.7 per cent of his 234 cases of carcinoma of the tongue. Forty-two per cent of these cases were early or borderline primary lesions which persisted in spite of treatment. Should these be those cases that were treated by radium, and I assume

they largely are, it is fair to suppose that in the best surgical hands a fair percentage of surgical cases would persist in spite of treatment. R. Phillips states that there is "an apparent superiority of radium over surgery in cases without node metastases" in cure rate of 40 and 27 per cent, respectively. Apparently, persisting primary disease would eliminate neck dissection in most of these cases. A fair percentage of these cases would also occur in the anaplastic group of tumors that are known to disseminate widely in the neck, mediastinum, and abdominal cavity and are, therefore, beyond the scope of surgical removal.

Another objection that might be raised is that the presence or absence of palpable lymph nodes cannot be depended upon as a guide to the presence or absence of metastasis. Morrow states that one-half of the cases with palpable nodes, and over one-third or 39 per cent without palpable nodes in his series showed cancer involvement on microscopic examination. Close interval observation as to the character of the lymph nodes, the care of infection in the primary lesion, its subsequent effect on the lymph nodes, and aspiration biopsy might at least to a certain extent satisfy this objection.

It is worth while to note that nodes probably do serve some protective process to the spread of tumor emboli, similar to acute inflammatory processes, and if removed when uninvolved might destroy this protective barrier. We all can probably recall cases in which distant metastases followed neck dissection, that we might think would not have occurred had neck dissection not been done. Quick states: "It is my opinion that a strictly normal cervical lymph node is capable of destroying regularly a tumor cell embolus of epidermoid carcinoma, and that metastasis takes place only in a lymph node damaged by infection or of otherwise lowered resistance."

If 40 per cent of the cases in these 5 year studies never develop metastasis, and if 60 per cent of the cases that are admitted without metastasis never develop metastasis, careful observation in the 28 per cent that will develop metastasis after admission[1], and the prompt dealing with the same once metastases do occur might be more conservative and accomplish somewhere near the same percentage of cures, rather than the custom of subjecting all patients without node metastasis to such a major surgical procedure as block dissection, either unilateral or bilateral, with its attending added mortality, discomfort, and complications that may arise. Operative mortality for neck dissections ranges between 2 and 10 per cent.

It is my personal opinion that when metastasis is not present a neck dissection is not indicated, and the patient can be cared for just as adequately when once metastases develop provided these patients are kept under strict observation. I believe that by so doing we will eliminate neck dissection in that group of odd-position metastasis high in the upper cervical group nodes, in the low supraclavicular nodes, distant nodes, and contralateral nodes that the most extensive neck dissection would probably fail to remove in most instances.

It seems reasonable that block dissection of the neck is not indicated unless the primary lesion is controlled, or shows reasonable hope that it can be controlled; also that transitional cell carcinoma and lympho-epithelioma, no matter in what stage of the disease, is a contra-indication to neck dissection. Both Duffy and Morrow report that about 20 per cent of metastases are bilateral. This also includes Grades 1 and 2 lesions. The question of surgical intervention here, in the presence of metastases, would depend upon the general condition of the patient, the life expectancy period aside from the disease itself, the question of the position, extent, and controllability of the primary lesion, the probability that operative intervention would give reasonable assurance of complete removal of the metastasis, that distant metastases could be ruled out, and that the tumor is of a highly differentiated cell type.

I personally question the advisability of bilateral block dissection, except in carefully selected cases with the above criteria as a guide when metastases are present; and can see little justification for block dissection in the absence of metastasis.

From the Curie Foundation we find these conclusions:

"Neck dissection is advised as soon as possible after the treatment of the primary lesion. Bilateral operation should be performed in all cases where the lesion has attained or passed beyond the midline."

There are other similar reports in the literature. However, it seems questionable whether primary lesions beyond the midline of the tongue promise sufficient hope for cure to warrant bilateral neck dissection. My ideas are in accord with Duffy in this regard.

When a case is selected for block dissection, it should be done with the most meticulous and painstaking care. This is no time or place for spectacular surgery. Haste often converts what might be successes into failures. It is imperative to realize at the start that the attempt is futile

[1]According to Duffy 28 per cent develop metastases after admission, and according to Martin 26 per cent.

unless it is sufficiently radical to remove all cancer-bearing tissue. Once block dissection is started, it should be with the end in view of cure and not palliation.

Surgery. Crile, Semken, Fischel, and others have interpreted what is to be included in this surgical procedure.

According to Semken in brief, it should consist of removal of the platysma muscle, complete removal of the submental nodes, submaxillary salivary gland and nodes, lower pole of the parotid, carotid, and posterior deep cervical nodes, to below the level of the omohyoid crossing. The internal jugular vein and sternocleidomastoid muscle are not removed unless involved.

An incomplete attempt at block dissection only increases the chance of wound recurrences, destroys the vascular bed for what effect radiation might have accomplished had neck dissection not been attempted, and invites complications and discomfort to the patient. Inadequate surgery under such circumstances is far inferior to good irradiation.

I personally prefer local anesthesia in most instances. The patient can co-operate with the surgeon, and there is greater tendency on the part of the surgeon for more delicate handling of tissues and less likelihood of postoperative pulmonary complications. Ether-oil rectal anesthesia, avertin, etc., are ideal in certain cases in which the objection to local anesthesia is raised for very prolonged and difficult operations.

There should be no hesitancy on the part of the surgeon to remove the internal jugular vein or the sternocleidomastoid muscle when there is questionable disease in the vicinity, or as an aid to thoroughness in the operative procedure.

Great care should be used to preserve vital structures: common carotid artery, vagus and phrenic nerves, the thoracic duct, etc. Fischel states that injury to the thoracic duct is usually of no serious import and will close in a few days time; but I can recall, personally, several severed thoracic ducts with continued loss of weight and exodus of the patient.

Ligation of the external carotid artery or its branches may be indicated (1) to control primary hemorrhage and (2) as a preliminary step to partial glossectomy for the treatment of late fibrosis, infection, and necrosis, following irradiation.

The common carotid artery may have to be removed occasionally, but this should only be done when the setting is most favorable for prolonged palliation, and in cases with reasonable hope of cure. The danger of cerebral complications following ligation of the common carotid artery should not be underestimated.

CONCLUSIONS

1. Lingual cancer metastasizes unilaterally, bilaterally, contralaterally, and with odd-position metastases remarkably early and with sufficient frequency that one must be on the alert for many possibilities in tongue cancer.

2. Operative intervention is indicated in all precancerous lesions and suspected early lingual cancer. Complete removal of the entire lesion is advocated.

3. Early fully established lingual cancer confined to the accessible locations of the tongue may be removed by surgery if of a fully differentiated cell type, in the absence of distant or bilateral metastasis, provided the general condition of the patient warrants the surgical risk, and in the event the life expectancy period aside from the disease justifies it.

4. In general, surgery is an adjunct to irradiation methods for the treatment of the tongue lesions.

5. Block dissection of the neck is indicated in fully differentiated carcinoma when the primary lesion is controlled or controllable, when the metastasis is limited to one side of the neck, and is in general confined within the capsule of the node, when the position of the metastasis permits the freedom of sacrifice of surrounding tissues sufficiently to insure complete removal of the metastases, and when the patient is a good surgical risk and the expectant period of life otherwise so warrants.

6. Bilateral block dissection of the neck may be advisable in carefully selected cases.

7. Block dissection, either unilateral or bilateral, is not indicated in the absence of metastasis.

8. Incomplete block dissections are responsible for many failures that otherwise might be successes in the hands of one trained in the practice rather than the mere theory of this type of major surgery.

9. There is a present day need for a more uniform tabular method of statistics in lingual cancer.

I wish to express my indebtedness to the authors quoted, and for their material to which I have referred. I trust I have not misquoted or misrepresented their deductions.

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MALIGNANT TUMORS OF THE NERVOUS SYSTEM AND HOW TO DEAL WITH THEM

ERNEST SACHS, A.B., M.D., F.A.C.S., St. Louis, Missouri

MALIGNANT tumors of the nervous system differ from tumors elsewhere in the body in a number of respects. The general conception of a malignant tumor is one which grows more or less rapidly, metastasizes, and ultimately causes the patient's death. Benign tumors elsewhere in the body, even when very large, rarely cause death. The following facts about brain tumors constitute the difference:

1. Primary cancer of the brain is very rare. In our series of more than 950 verified brain tumors we have encountered only 3 or 4 patients who were diagnosed as primary carcinoma cases but none of these metastasized. In this series, however, we have seen 38 metastatic carcinomas. Sarcoma, though somewhat more frequent, also constitutes a very small percentage, and these may metastasize.

2. No tumor which has its origin in the brain, that is, a primary brain tumor, metastasizes.

3. Practically every patient with a brain tumor dies as a result of the growing tumor unless it is removed or destroyed. The length of time a patient may live varies considerably, depending upon the type and location of the tumor; but the ultimate outcome, without operation, is always the same.

TYPES OF TUMORS

The great majority of tumors which develop in the brain itself are some form of glioma. Almost all which grow from the meninges are meningiomas, and in addition, these are tumors which grow from the nerve sheaths of which the acoustic neuromas are the most common.

For the past 12 years neurological surgeons and neuropathologists have differentiated the gliomas into various groups depending upon the predominating cell type. As a result, we recognize 8 to 10 different tumor groups. At one end of the scale are those that grow rapidly, namely, the glioblastomas, also called spongioblastoma multiforme, and the medulloblastomas, while at the other end are the slow-growing tumors, or ependymomas, oligodendrogliomas, and astrocytomas.

The fact that a tumor does or does not metastasize, though one of the most important criteria of malignancy, is not the only one. The presence of mitoses and the fact that a tumor invades surrounding tissue are points that must be considered when evaluating the nature of a tumor.

The glioblastomas, if they present on the surface, may have a sharp line of demarcation; but as the surgeon gets into the depths when removing them, this line of demarcation disappears and it may be very difficult for him to distinguish normal from abnormal tissue (Fig. 1). When such a tumor is examined histologically, it may be found to have many mitoses. Medulloblastomas, the one type of tumor that is extraordinarily radiosensitive, may also have a sharp line of demarcation and at times almost a capsule; but in spite of radical surgery, there are thus far only a few instances in which there has not been a recurrence. Still more radical procedures may result in a larger number of cures.

From the Neurosurgical Service of Washington University School of Medicine, the Barnes and St. Louis Children's Hospitals.
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The slow-growing tumors at the other end of the scale, the ependymomas, oligodendrogliomas, and astrocytomas, often contain calcification; they may be well demarcated yet have some mitotic figures (Figs. 2, 3, and 4).

The absolutely benign gliomas, known as astrocytomas, are encapsulated, often cystic, and rarely contain any mitoses.

Meningiomas, the tumors that grow from the meninges, are well encapsulated and as they grow they compress the brain tissue. Because they grow slowly, it is sometimes years before they give rise to symptoms which bring the patient to the surgeon. A certain number, fortunately not very many, contain mitotic figures and grow more rapidly. These may be softer but they also have a capsule. From their gross appearance it is quite impossible to distinguish the meningiomas without mitoses from those with mitoses, though the softer consistency may make one suspicious.

The important question that arises is, Can these types of tumors be recognized clinically?

If this were possible, it would be invaluable both for prognosis and treatment. There might be 2 ways of distinguishing them: (1) By their location, on the theory that certain tumors are found in certain areas of the brain, and (2) by the symptoms to which they give rise.

There is no question that certain types of tumors develop far more frequently in some regions of the brain than in others. Glioblastomas occur almost invariably in the cerebral hemispheres. In our series of 106 glioblastomas 100 were found in the cerebrum and only 6 in the cerebellum. They may grow in any portion of the cerebral hemisphere, and there is no reliable evidence to indicate that they affect one lobe more than another. It is quite true that we see many more of these tumors in the frontal, parietal, and temporal lobes than in the occipital lobe, but they occur there also. I know of no good explanation why the occipital lobe should be less frequently involved than the others, but this has been the general observation.

Medulloblastomas, the type that is radiosensitive, occur most often in children, though not infrequently in young adults. In the majority of cases they grow in the posterior fossa, yet this tumor has been encountered in the cerebrum also. In our series 53 were found in the cerebellum and only 7 in the cerebrum.

Astrocytomas, the most benign type of glioma, are very often cystic; usually there is only 1 cyst with a nubbin growing in the wall. In order to cure such a case, this nubbin must be completely removed. Emptying the cyst is only a palliative procedure, though it may give relief for many years. One such patient in whom the cyst was merely emptied was operated upon in 1926, 14 years ago, and is still free of symptoms. On the other hand, this year I re-operated upon a young woman of 35, whose cyst I first opened 25 years ago; 8 years later I removed the nubbin of this cyst, as I thought, completely, and in 1939, 17 years afterward, she returned with symptoms due to a recurrence. It is generally claimed that this type of tumor occurs more frequently in the posterior fossa, but in our series 66 cases were found in the cerebrum and 44 in the cerebellum. The solid astrocytomas very occasionally have some calcification around the periphery of the tumor (Figs. 4, 5a and 5b).

There is another type of glioma, the unipolar spongioblastoma, not hitherto mentioned, which also develops in a definite region of the brain. These occur practically always in the midbrain, pons, and medulla. They are ill defined, and shade off imperceptibly into the surrounding normal brain substance. For this reason, though even more because of their location, these are the only tumors that everyone agrees are inoperable.

Astroblastomas, a very rare type of tumor, may occur in either the cerebrum or cerebellum. They are, as a rule, rapid growing tumors, but this is not always the case. For example, I removed an astroblastoma recently from a young man who had had symptoms for 3 years. A year after his symptoms began he had an exploration at another clinic, at which time a specimen was excised which showed the same histological picture as the tumor that we removed 2 years later.

Meningiomas occur anywhere in the cranial cavity but in most instances above the tentorium. In our series 104 were found in the cerebrum and 5 in the posterior fossa. They often contain calcium, which is deposited in a characteristic way, making the diagnosis possible from a roentgenogram (Figs. 6 and 7). Usually they grow slowly, over a period of months or years, but at times develop as rapidly as some gliomas.

From what has just been said it should be evident that by the location of a tumor one cannot predict with any degree of certainty the type of tumor he will find at operation.

The second question to consider is, Can these types of tumors be determined by symptoms and signs?

The 2 most rapidly growing tumor types are the glioblastomas and the medulloblastomas, and, as I have just pointed out, the former occur most frequently in the cerebral hemispheres and the latter in the posterior fossa. Therefore, one might suspect that he is dealing with 1 of these 2 types

Fig. 1. Glioblastoma showing the way in which the tumor imperceptibly fades into normal tissue so that there is no clear line of demarcation.

if the patient's symptoms have been present only a short time, though undoubtedly a patient may harbor a tumor for some time before it gives rise to any recognizable symptoms. Then, too, how shall one define "a short time"?

The fewest patients with brain tumors, when first seen, have had symptoms for less than 6 weeks, while the majority have had them for a considerably longer time. I have taken out meningiomas that have given symptoms for only 2 months, and have seen glioblastomas that have produced symptoms for several years. As a rule, however, a cerebral tumor that has given symptoms for only a month or two is most likely to be a glioblastoma, and a cerebellar tumor with a short history is more than likely a medulloblastoma.

Another difficulty enters into the picture. What shall we call the first symptom?

Fig. 2. Ependymoma with very slight calcification in it opposite the arrow.

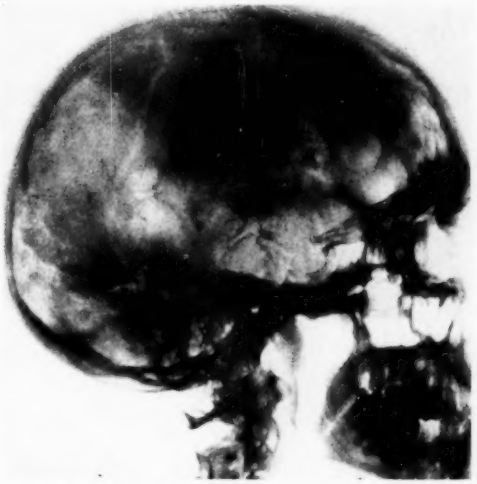
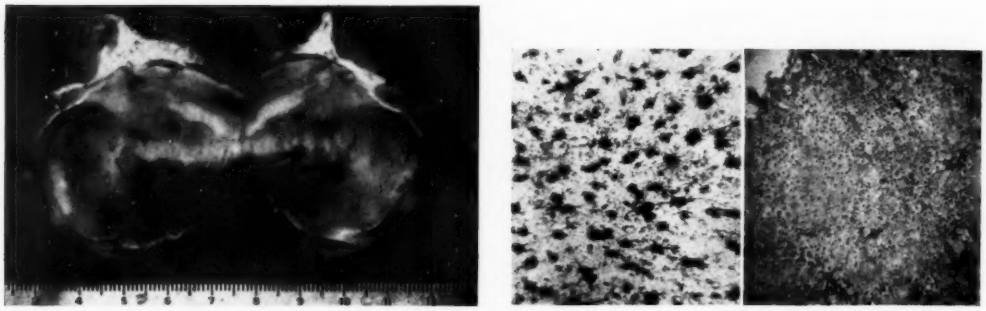


Fig. 3. Characteristic loose cotton-like appearance of calcification in an oligodendroglioma.

Some years ago when studying the incidence of convulsions in patients with brain tumors, Dr. Furlow and I found that in about one-third of all of our patients, one or more convulsions occurred often months before any other sign or symptom was noted. We believe that convulsions, either general or focal, are frequently the earliest warning of the presence of a tumor; and since they may precede all other symptoms by months or even

Fig. 4. Calcification in a solid astrocytoma. Histological view in Figure 5b.



a b

Fig. 5. a, The solid astrocytoma shown in Figure 4 with normal brain tissue around it. b, Typical picture of an astrocytoma, low and high power.

years, the "short time" we have spoken of loses much of its value.

A further question is: Do some of the symptoms and signs occur more frequently in one type of tumor than in another?

Again, it would be very helpful if they did, but unfortunately they do not. Both slow growing and rapid growing tumors may sometimes produce focal symptoms first, and at other times general signs of pressure. Either a meningioma or a glioblastoma in the precentral gyrus may have as its first symptom a partial paresis of an extremity, or, on the other hand, headache and the other signs of increased pressure.

While it is true that the symptoms may follow one another much more quickly in a rapid growing tumor, there is no rule that can be laid down on this point. Everyone has seen meningiomas attain a very great size without producing any disturbance, and then quite suddenly give rise to a series of symptoms. On microscopic study of such a tumor there is no evidence that any rapid growth has recently occurred.

In children with symptoms of a cerebellar tumor fully 50 per cent are medulloblastomas; but as this type gives no characteristic symptoms, all one can do is to surmise what type of tumor the patient has. We cannot be positive.

A very few neurosurgeons are so conservative that purely on a chance they first treat such patients with deep therapy, hoping the tumor may be radiosensitive, but in most neurosurgical clinics the feeling is that a patient should not be treated with deep roentgenotherapy until the type of tumor has been ascertained histologically. Surely, this is the intelligent, constructive, and progressive way to approach the problem.

Here, then, is the situation we are faced with:

Figs. 6 and 7. Two examples of calcified meningioma.

No primary brain tumors metastasize, but a considerable number are not sharply demarcated and fully 50 per cent contain mitotic figures.

Symptoms and signs do not indicate the pathological type we are dealing with, nor do any of the methods of localization roentgenography or ventriculography, help in determining them.

Practically no brain tumors meet all the requirements that are generally conceded necessary to constitute malignancy. Certainly, the most important one of metastasizing is totally lacking. Brain tumors must be judged by different pathological standards. Just because they infiltrate and have mitoses they need not be considered malignant in the sense that carcinoma and sarcoma are malignant. Consequently, they should not be treated as are malignancies elsewhere in the body.

TREATMENT

We all look forward to the time when some other, more effective method than surgery may be discovered for the treatment of tumors. But at the present time nothing has been found to replace surgery in the treatment of deep-seated carcinoma or brain tumors. Most surgeons believe, I know I do, that operations which are only palliative are thoroughly justifiable. Even if we cannot cure a patient, to give him a period of comfort for months or even years is well worth while. By continuing to operate upon patients whom we think we may only relieve we may be able to improve our technique to such a degree that a surgical cure may be affected. Certainly, this has been shown strikingly in surgery of carcinoma of the stomach.

I tried to make this point 2 years ago in an editorial in SURGERY, GYNECOLOGY AND OBSTETRICS on "The Radical Versus the Conservative Treatment of Brain Tumors." In a very recent book I have been grossly misquoted. It was said that I advocated attempting to remove brain tumors regardless of the result for the patients, and that radical treatment in the removal of a tumor containing mitotic figures is like operating upon a carcinoma of the pancreas that has metastasized to the liver. In the light of what I have just said, such a comparison is hardly justified. Because a tumor contains mitotic figures and may not be sharply demarcated is no reason to throw up one's hands and declare all such tumors unremovable. This attitude is most unfortunate. It overemphasizes the microscopic picture, which, after all, is only the means to an end, and totally ignores surgical experience and increasing surgical skill. This is accepting defeat without even admitting the possibility of progress.

Brain tumors can be removed and we have no other means of giving patients even temporary relief except, very occasionally, with deep roentgenotherapy. Sometimes a radical removal leaves the patient with some disability. For example, removal of a tumor from the motor area may leave the patient with a partially paralyzed arm or leg, but if not removed, the tumor itself will produce such a paralysis before long. In my experience patients willingly accept such a disability, if told of it before the operation, in the hope of obtaining relief.

It is impossible, of course, to lay down hard and fast rules that will cover every case. Surgical judgment based upon experience will enable the surgeon to know how far he should go, and when he should stop; but in general, for the reasons given above, operative removal should be undertaken irrespective of the histology of a tumor. Since brain tumors do not metastasize and are entirely a local disease, our attitude in the handling of all types of brain tumors is always the same. Whenever technically possible, a brain tumor should be removed.

THE SURGICAL TREATMENT OF CARCINOMA OF THE THORACIC ESOPHAGUS

JOHN H. GARLOCK, M.D., F.A.C.S., New York, New York

UNTIL recently, progress in the surgical treatment of esophageal carcinoma was necessarily slow. Due mainly to the rapid strides made in the fields of thoracic surgery and anesthesia, a few surgeons have been encouraged to attempt excision of the esophagus for cancer. This has resulted in an increasing number of successful resections during the past 4 or 5 years. Of the 15 to 20 patients so treated, the great majority were reported during this period.

A great factor in the retardation of progress in this field of surgery has been the assumption on the part of the medical profession that the operative procedure carries with it an enormously prohibitive mortality. In the early days this assumption was probably correct and served to emblazon with glory the first successful resection performed by Torek in 1913. It is to eliminate this fear on the part of the profession that the experiences of surgeons in this field should be constantly brought to their attention by published reports.

Heretofore, the diagnosis of carcinoma of the esophagus was tantamount to signing the patient's death warrant and the physician advised palliative measures consisting of gastrostomy, radiation therapy, or both. Under these circumstances, the average span of life was approximately 6 months. The rare case lived for more than 1 year. Yet, in spite of this hopeless outlook, most radiologists have questioned the wisdom of subjecting such patients to operation and have considered a successful outcome in the nature of a surgical feat not inconsiderably mixed with a good portion of luck. Some years ago, this point of view probably possessed an element of truth, but, I wish to emphasize that, in the light of recent experiences, it no longer holds water. The low operative mortality in the series of cases which I have already reported and the additional operations to be described cannot be considered in the nature of a surgical feat, but rather one dependent upon early diagnosis, careful pre-operative preparation, a sound operative procedure based on our present day conception of radical cancer surgery, expertly administered anesthesia, meticulous postoperative care, and the immediate treatment of complications as they arise. This calls for maximum effort on the part of a well-trained, closely-knit organization of operating-room personnel, anesthetist, nurses, physician, and surgeon.

In 2 previous papers I reported 6 cases of patients with esophageal cancer who were treated surgically, stressing the importance of early diagnosis, the need of careful pre-operative preparation, the problem of anesthesia, and the details of the operative procedure. Now I should like to report 4 additional cases and take up the problem of carcinoma at the lower end of the esophagus, especially with respect to its operative management.

I wish again to emphasize the importance of early diagnosis and the need of regarding with great suspicion any change in the act of swallowing in a person past 35 or 40 years of age. This calls for immediate roentgenographic examination by a competent radiologist. There is need for haste in arriving at a diagnosis, because, frequently these tumors grow rapidly and may quickly reach the inoperable stage, and this diagnosis should be made before great weight loss has occurred. Any deviation from the normal in the roentgenogram demands esophagoscopic examination. No patient should be subjected to operation unless a biopsy has been performed and the tissue pronounced carcinoma.

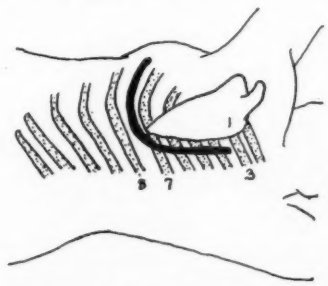


Fig. 1. Incision is made in the seventh interspace, starting in the mid-clavicular line and carried posteriorly. It extends upward between the vertebral border of the scapula and the spinal column. The seventh, sixth, fifth, and fourth ribs are divided about an inch lateral to the transverse vertebral processes.

From the Surgical Service of Mt. Sinai Hospital.

Presented in the Cancer Symposium before the Clinical Congress of the American College of Surgeons, Philadelphia, October 16–20, 1939.

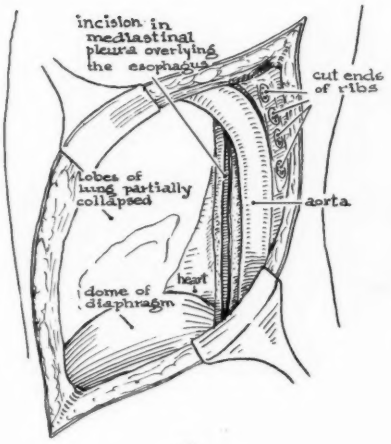


Fig. 2

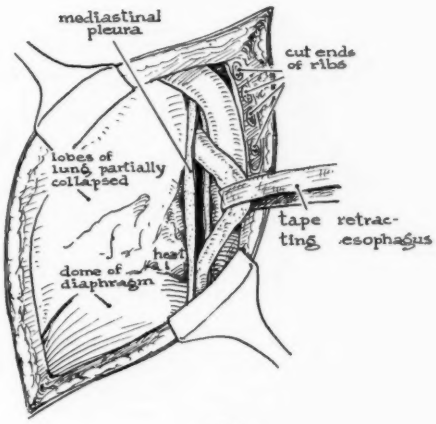


Fig. 3

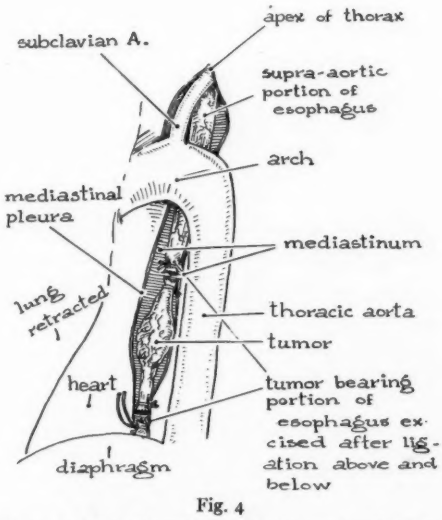


Fig. 4

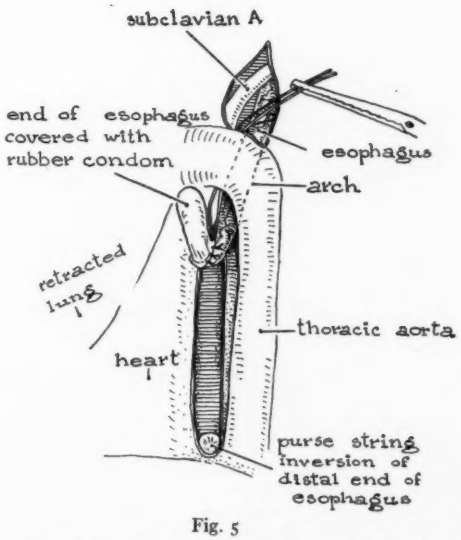


Fig. 5

Fig. 2. An incision is made in the infra-aortic mediastinal pleura, mesial to the aorta in order to expose the esophagus.

Fig. 3. The esophagus is dissected from its attachment and a tape is placed about it. Traction on the tape aids considerably in freeing the organ.

Fig. 4. The mediastinal pleura above the arch is incised and the esophagus is freed from the surrounding structures. The tumor-bearing portion of the organ with a wide margin of normal tissue is removed after double ligation and division.

Fig. 5. The divided end of the esophagus has been covered with a rubber condom which is sutured to the esophageal wall. The distal end of the esophagus is inverted into the stomach. The mediastinal pleura is not sutured. The infra-aortic portion of the esophagus is brought to lie above the arch.

I have, on previous occasions, stressed the need for careful pre-operative preparation and indicated, in detail, what this involves. Suffice it to say that it should include a high caloric intake, the administration of large quantities of fluid to overcome the dehydration which is frequently present, careful attention to mouth hygiene, and transfusions. If the carcinoma is located in the

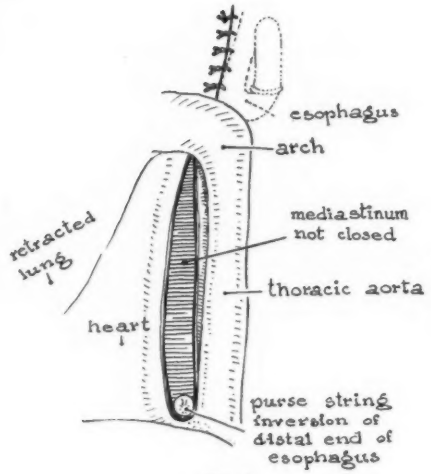


Fig. 6

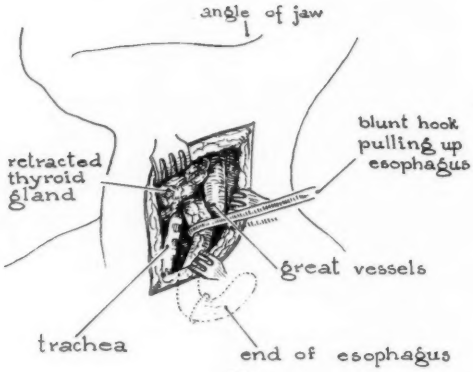


Fig. 7

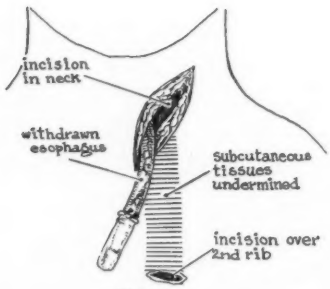


Fig. 8

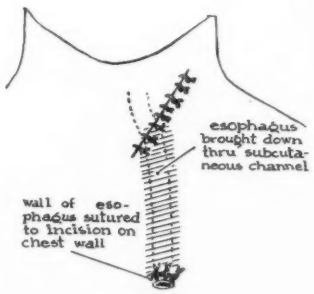


Fig. 9

Fig. 6. The mediastinum below the arch is left open to permit of drainage of the cellular tissues. The pleura above the arch is sutured in order to close off the neck from the pleural cavity. The rubber-covered end of the esophagus has been pushed into the neck.

Fig. 7. Second stage of the operation. The cervical portion of the esophagus is exposed and the end of the organ covered by the rubber envelope, as indicated in the dotted lines, is drawn out of the wound.

Fig. 8. A subcutaneous channel is made, extending from the lower end of the cervical incision to about the region of the second rib.

Fig. 9. The esophagus is drawn through the channel so that its end projects beyond the skin incision for a distance of an inch. The incision is sutured to the wall of the esophagus with interrupted stitches of fine silk.

(Figures 5 to 9 reproduced through the courtesy of the *New International Clinics*, Vol. 1, Series 2.)

proximal two-thirds of the organ, a preliminary permanent gastrostomy will be indicated. During the 7 to 10 days following the gastrostomy, considerable improvement may be noted. High caloric fluid food containing the necessary vitamins and minerals should be given frequently through the gastrostomy tube. Additional food should be taken by mouth in order to obtain the beneficial effects of the admixture of saliva.

If the carcinoma is located in the terminal 2 or 3 inches of the esophagus, preliminary gastrostomy should not be done, because, in such cases, a 1 stage operation is now advocated, with reestablishment of continuity of esophagus and stomach by the performance of an intrathoracic esophagogastrostomy. The presence of a gastrostomy would greatly complicate this procedure. I have been considering the performance of a preliminary jejunostomy for feeding purposes, but have not done so because I have felt that the upper abdominal adhesions caused by the jejunostomy might render the subsequent operation

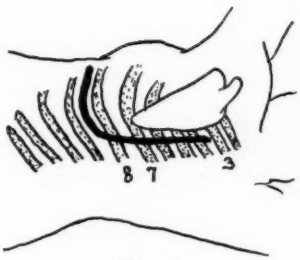


Fig. 10

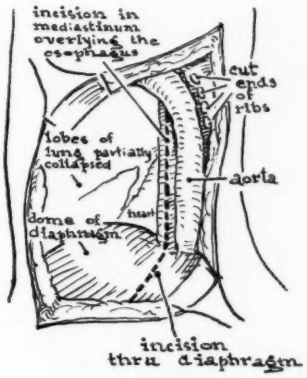


Fig. 11

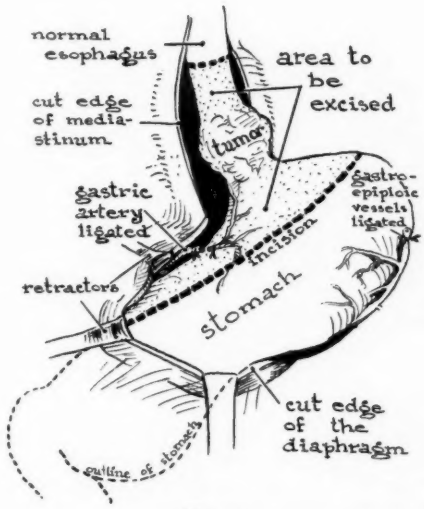


Fig. 12

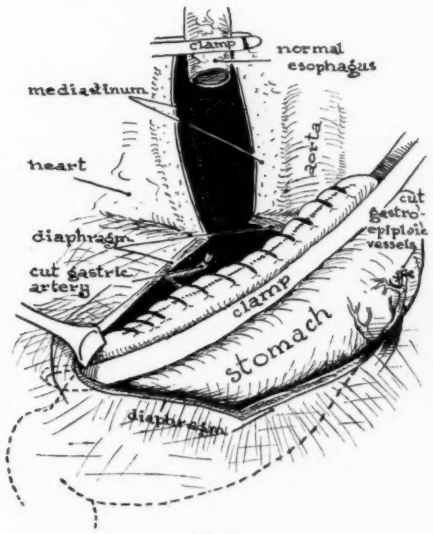


Fig. 13

Fig. 10. Operation of resection and esophagogastrostomy. Incision in eighth interspace. The eighth, seventh, sixth, and fifth ribs are divided near the transverse vertebral processes.

Fig. 11. Incision made in mediastinal pleura. The diaphragm is split radially outward from the esophageal hiatus.

Fig. 12. The tumor-bearing portion of the esophagus and the cardia have been separated from the mediastinum and the diaphragm. Mobilization of the stomach is accomplished by ligation and division of the gastric and left gastro-epiploic vessels.

Fig. 13. The stomach is resected in an oblique direction well beyond the growth and is closed with 2 layers of silk sutures. The esophagus is transected well above the cancer. A small rubber-covered clamp prevents soiling.

more difficult. The smooth convalescence of the patients subjected to the 1 stage operation seems to justify this viewpoint.

Because the operation for esophageal cancer is performed by the transthoracic route, it has been stated by 1 or 2 writers that it is advisable to establish pneumothorax on one or more occasions prior to operation in order to accustom the lung to the differences in pressure incident to the operative procedure. I have not seen the need for this up to the present time and have noted no complications which could have been obviated by

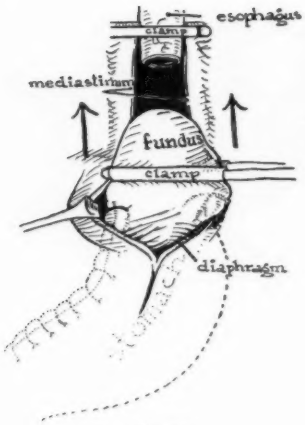


Fig. 14

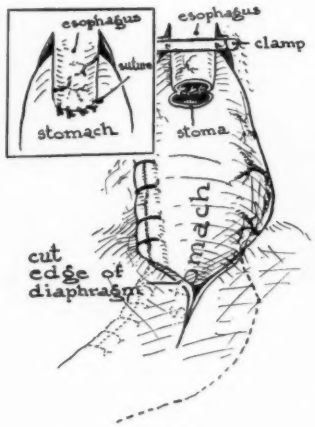


Fig. 15

Fig. 16

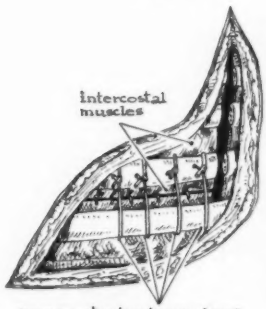


Fig. 17

Fig. 14. The stomach is drawn upward into the thoracic cavity and its upper end brought into position for anastomosis with the esophagus.

Fig. 15. An end-to-side anastomosis in 2 layers is effected in the same manner as one performs gastro-enterostomy. Silk sutures are used. Care should be taken to avoid strangulation of tissues. Insert shows the completed anastomosis.

Fig. 16. The esophagus is telescoped into the stomach by drawing the stomach upward in a sleeve-like manner. To maintain this position, the stomach is tacked down to the esophagus and also to the mediastinal pleura with interrupted stitches of silk. The remainder of the mediastinum is left open. The opening in the diaphragm is partly closed, the remaining edges being sutured to the stomach wall in order to prevent herniation.

Fig. 17. The thoracic wound is closed by encircling the contiguous eighth and ninth ribs with heavy catgut sutures.

preliminary pneumothorax treatment. Reliance has been placed mainly on an expertly administered ethylene anesthesia, with varying degrees of positive pressure during the operation to vary the extent of lung inflation. The successful outcome of the operation is in no small measure dependent upon the skill of administration of the anesthetic agent.

OPERATION

For cancer located in the upper two-thirds of the thoracic esophagus radical resection by the modification of the original Torek procedure described in my last paper is the operation of choice. On the basis of considerable experimental and some clinical work it has been determined that it is impossible to resect a portion of the thoracic esophagus, perform an end-to-end anastomosis, and obtain satisfactory union and continuity of the viscus. The reasons for this are: (1) In order to effect a radical removal too large a section of the organ would necessarily be removed to permit bridging of the gap without great tension at the subsequent suture line. (2) The esophagus is devoid of celomic covering which is so important in satisfactory healing. (3) The longitudinal muscle fibers surrounding the esophagus exert so strong a pull that any type of anastomosis is quickly torn apart.

This operation has been described in detail in 2 previous publications. Figures 1 to 9 will indicate the essential steps. Briefly, the procedure entails a left transthoracic approach, mobilization of the entire thoracic esophagus, resection of the tumor bearing portion with a wide margin of normal organ on each side, leaving the mediastinum open to drain its cellular tissues, closure of the chest wound with establishment of under water drainage, mobilization of the cervical

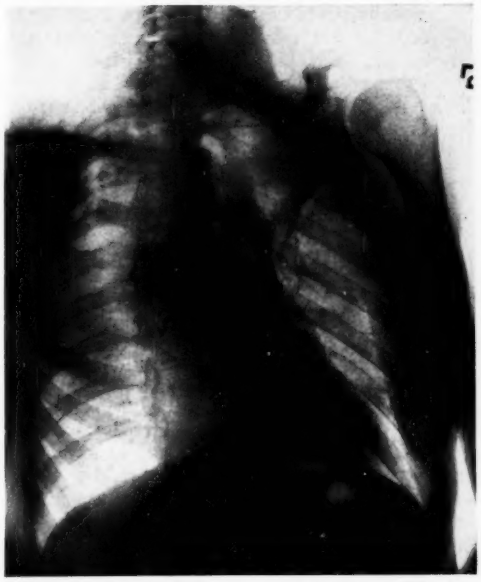


Fig. 18. Case 4. Roentgenogram of esophagus showing stenotic filling defect at the level of the arch of the aorta.

esophagus through an oblique neck incision, and the establishment of an esophageal fistula at about the level of the left second rib anteriorly. Continuity of the organ is later established by artificial means in the form of a removable rubber tube which connects the esophageal fistula and the gastrostomy opening.

When the growth is located in the terminal 2 to 3 inches of the esophagus, every effort should be made to establish continuity of esophagus and stomach by a suture anastomosis. Sufficient evidence has been accumulated up to the present time to warrant the statement that the operation of intrathoracic esophagogastrostomy (end-to-side) is entirely feasible and is followed by solid healing with minimal diminution in the caliber of the lumen. I have, up to the present time, performed this operation 4 times, once for an esophageal cancer and 3 times for cancer at the cardiac end of the stomach. The latter group will form the basis for a subsequent paper. The autopsy specimen of one of the stomach cases shows solid healing at the site of anastomosis without stricture formation (Fig. 29).

The operation, a modification of the original Sauerbruch and Fischer procedures, consists of a transthoracic approach, incision of the diaphragm, mobilization of the upper two-thirds of the

Fig. 19. Case 4. Gross specimen showing complete encircling of esophagus by the neoplasm.

stomach, resection of the tumor bearing area, the performance of a careful suture anastomosis between the end of the esophagus and the anterior wall of the stomach in 2 layers, and the telescoping of the esophagus into the stomach by drawing the latter organ upward in a sleeve-like manner around the esophagus in order to minimize any possible drag on the suture line.

The details of the operation are as follows: The patient is placed on his right side with the head resting on the abducted right arm and his back close to the edge of the operating table. The incision begins in the eighth interspace in the anterior axillary line and is curved posteriorly and ex-

Fig. 20. Case 4. Photograph of patient 6 months after operation showing the rubber esophagus in place.

Fig. 21. Case 5. Gross specimen showing marked stenosis and small submucous metastatic nodules.

tended upward between the spine and vertebral border of the scapula as far as the fourth rib (Fig. 10). The thoracic musculature is divided in the line of the skin incision. All bleeding points

Fig. 22. Case 6. Roentgenogram of esophagus and stomach showing the irregular defect at the lower end of the esophagus extending into the cardia.

are carefully ligated before the thoracic cavity is entered. An incision is made in the eighth interspace dividing the parietal pleura with the intercostal muscles. The eighth, seventh, sixth, and fifth ribs are quickly divided about 1 inch from the spine and the intercostal vessels are ligated with hemostatic sutures. Use of a rib spreader gives an excellent exposure of the left thoracic cavity. The inferior pulmonary ligament is divided which permits collapse of the lower lobe. Complete pulmonary collapse should not be permitted to take place. This can be controlled by the anesthetist.

The growth is now palpated. Intimate fixation to the aorta or vertebral column renders the case inoperable. A vertical incision is made in the mediastinal pleura mesial to the aorta from the arch down to the diaphragm (Fig. 11). The esophagus is identified and freed bluntly from the mediastinal tissues. It is important to ligate the small esophageal vessels, but care should be taken not to jeopardize the blood supply of the esophageal stump to be utilized for the anastomosis. Fixation to the right mediastinal pleura should not deter the surgeon. I have encountered this complication on 3 occasions and have in each instance excised a portion of the right pleura in order to effect a radical removal. The defect may be closed quite easily by utilizing the stomach wall after it has been mobilized.

An incision is then made in the left leaf of the diaphragm, extending from the esophageal hiatus radially outward toward the ribs for a distance of 6 or 7 inches (Fig. 11). The esophagocardiac junction is freed bluntly from its loose attachment to the diaphragm. The spleen and fundus

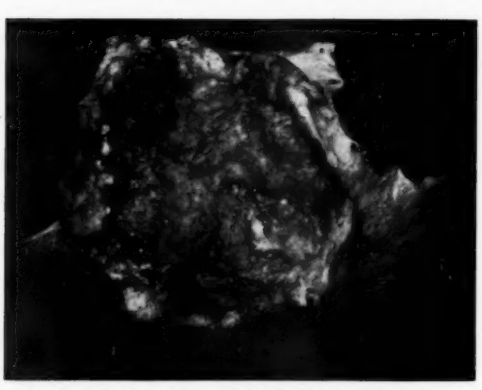


Fig. 23. Case 6. Gross specimen showing a large circular ulcerated neoplasm. There were no involved lymph nodes.

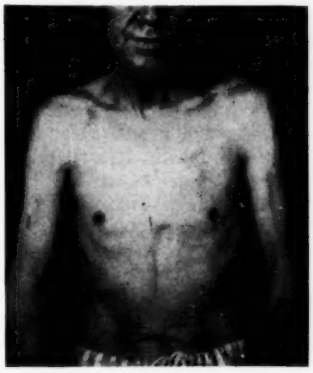


Fig. 24

Fig. 25

Fig. 24. Case 6. Photograph of patient taken 30 days after operation.
Fig. 25. Case 6. Rear view of patient 30 days after operation, showing the well healed wound and the thoracotomy scar.

of the stomach quickly appear in the wound. Judicious retraction of the edges of the diaphragmatic opening and the insertion of gauze packs will expose adequately the proximal half of the stomach. The left gastro-epiploic vessels are ligated and divided which permits the surgeon to enter the lesser sac. By inserting the left hand in the lesser sac and drawing the stomach downward, it is not difficult to isolate the gastric artery near its origin and to divide it after careful double ligation. Complete mobilization of the proximal half of the stomach is obtained following division of its ligamentous attachments at the upper part of the greater curvature. The stomach may now be drawn up into the thoracic cavity with ease (Fig. 12).

During the resection of the growth and the subsequent anastomosis the entire chest cavity and wound must be protected from contamination. I regard the details of this part of the operation of great importance. Long rubber covered clamps are placed on the stomach side beyond the growth in an oblique direction from the upper greater curvature toward the lesser curvature and the stomach is divided with the carbolic acid cautery. The opening in the stomach is closed in 2 layers with silk, and care should be taken to ligate separately all bleeding points (Fig. 13). A small rubber covered non-crushing clamp is now placed over the esophagus well above the tumor. A second crushing clamp is placed about ¾ of an inch beyond this and the esophagus is divided so as to leave at least ½ inch of the organ projecting beyond the rubber covered clamp. The specimen is removed.

The upper end of the stomach in the region of the greater curvature is brought in approximation to the esophageal stump (Fig. 14). A 2 layer suture anastomosis, end-to-side, is now performed between the end of the esophagus and the anterior wall of the stomach at a point about 2 inches

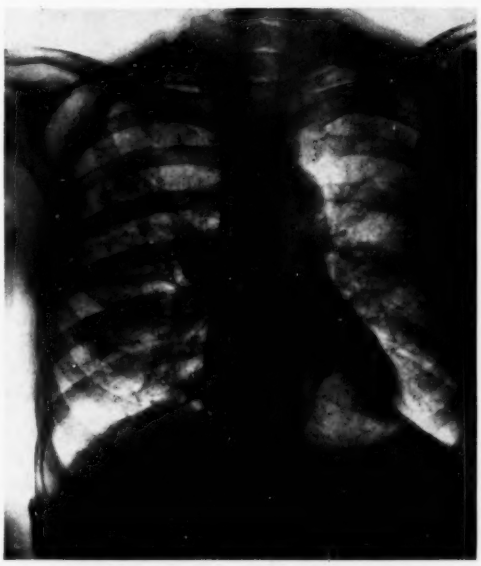


Fig. 26. Case 6. Roentgenogram of esophagus and stomach taken 28 days after operation, showing the intrathoracic position of the stomach and the adequate new stoma between esophagus and stomach.

Fig. 27. Case 7. Roentgenogram of esophagus indicating an obstructing lesion at the level of the aortic arch.

beyond its upper end (Fig. 15). The inner layer is a continuous Connell suture of fine silk uniting mucosa and submucosa. Every stitch must be correctly placed. It is important to avoid strangulation of the tissues. The second layer is a continuous Lembert suture of fine silk, joining muscularis of esophagus to the muscle and peritoneal layers of the stomach. In order to protect the suture line from longitudinal tension, the stomach is drawn upwards like a sleeve over the suture line and is anchored in this position by interrupted sutures of fine silk which include the muscularis of esophagus and the cut edges of the mediastinal pleura (Fig. 16). The new anastomosis will usually be situated an inch or two below the arch of the aorta and it will be seen that approximately one-half of the stomach now occupies an intrathoracic position.

The radial incision in the diaphragm is now closed with interrupted sutures of silk; care is taken not to make the opening through which the stomach emerges too small. To prevent herniation of more stomach into the chest, the edges of the diaphragmatic opening are sutured to the stomach wall (Fig. 16).

Through a small stab wound in the subjacent intercostal space a soft rubber tube is inserted for under water drainage. The thoracic wound is repaired in the usual manner by encircling the contiguous eighth and seventh ribs by heavy chromic sutures (Fig. 17). The chest musculature is carefully repaired layer by layer and the skin is closed with silk. The anesthetist inflates the lungs, thus helping the escape of air in the pleural cavity through the intercostal drainage tube, the end of which has been placed under water. A snug dressing is applied so as to support the severed ribs.

Every patient reported in this series of cases has received a transfusion of 500 cubic centimeters of blood during the course of the operation. It has been both surprising and gratifying to see these patients go through this extensive procedure with little evidence of shock. The pulse has varied between 80 and 128. The blood pressure readings have shown very little variation; a slight drop occurred during ligation of the gastric artery and mobilization of the stomach. I believe that it is important to emphasize the fact that the various steps of this operation must be carried out with great gentleness and with minimal trauma to the lung parenchyma.

POSTOPERATIVE CARE

Before this operation is undertaken it is very important to explain to the patient that he must not swallow for a period of 5 or 6 days. The processes of repair at the suture line will be hastened by the full co-operation of the patient in this respect. To supply fluids, use is made of the con-

Fig. 28. Case 7. Gross specimen of resected esophagus, showing a large punched-out ulceration with firm overhanging edges and a necrotic base. In the gross, this is similar to the epitheliomas of the lips, tongue, and skin.

tinuous intravenous drip of 5 per cent glucose in normal saline. It may be necessary to give another transfusion during the first day or two. I have placed the last 3 patients in an oxygen tent immediately following the operation. It is my impression that these patients have had much less difficulty with breathing, and it may be a factor in the prevention of postoperative pneumonia. It is important to administer sufficient morphine to keep the patient quiet and comfortable.

I have been considering the idea of passing a Levin tube at the time of operation beyond the suture line into the stomach for feeding purposes. However, Bohrer's recent experience with a case in which this was done strengthened my belief that it would not be without danger. The situation at the suture line is precarious enough without adding the danger of pressure necrosis from a Levin tube.

The character of the material draining through the intercostal tube will indicate the progress of the intrathoracic situation. During the initial 24 to 36 hours the fluid is frankly bloody. After this it gradually assumes a lighter color and decreases in amount until about the seventh or eighth day when it usually stops completely. The tube may be removed about the tenth day.

Small sips of water may be given on the fifth or sixth day. If nothing appears through the drainage tube, it is assumed that the suture line has healed and is intact. Increasing amounts of liquid are now given until about the sixteenth day when custards, gelatins, cereals, etc., are permitted. The diet is rapidly increased thereafter. Solid food should not be given until the third or fourth week. In none of the patients has there been any indication of stricture formation at the site of anastomosis.

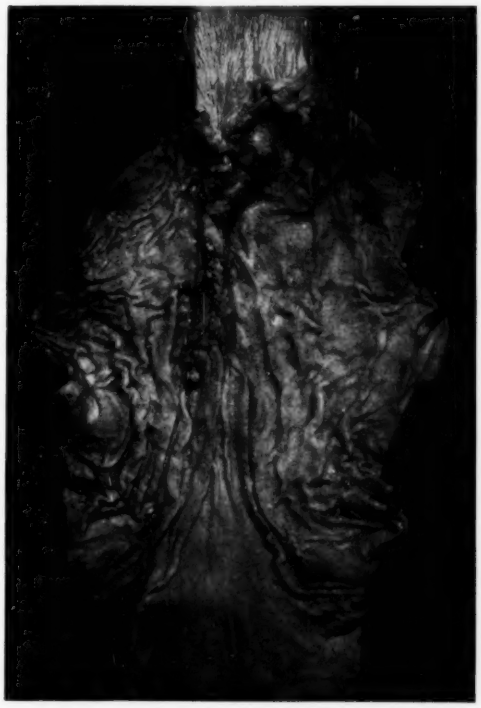


Fig. 29. Postmortem specimen. This patient had a resection and transthoracic esophagogastrostomy performed for carcinoma of the cardia. He died of a cerebral embolus on the fourth day. The suture line is intact and healing has progressed sufficiently to render the new stoma water tight. The telescoping of the esophagus into the stomach may be seen at the right corner of the anastomosis. This case will be reported at a later date.

RESULTS

Up to the present writing I have operated upon 10 patients with carcinoma of the thoracic esophagus. Three, who were previously reported, were found inoperable, making an operability percentage of 70. Of the 7 remaining patients, 6 survived the radical operation, making the mortality rate 14.2 per cent. Follow-up observations of the first 3 patients were published recently, but I wish to repeat them briefly at this time:

Case 1 died of a recurrent tumor in the superior mediastinum 22 months after operation. Case 2 is alive and well 2 years and 11 months after the radical resection. Case 3 died 3 months after operation of coronary artery disease. At autopsy no remaining evidence of cancer was found.

The 4 remaining cases are being reported now for the first time. The patient in Case 4 is alive 1 year after operation. The patient in Case 5 succumbed to operation. In Case 6, patient had a resection with intrathoracic esophagogastrostomy, and is alive and well 8 months after operation. The patient in Case 7 was operated upon recently and is doing well.

We may summarize our results as follows: Of 7 patients subjected to radical resection, 6 survived the operation. Of these 6 patients, 4 are alive and well.

In addition to these 7 cases of primary carcinoma of the esophagus, I have performed radical resection and intrathoracic esophagogastrostomy in 3 instances of carcinoma originating at the cardia and secondarily involving the lower esophagus. These cases will form the basis of a subsequent publication. Suffice it to say at this time that, from this experience, I am convinced that the only logical method of treating cancer in this

situation is by the transthoracic transdiaphragmatic route detailed in this paper. It is my belief that none of the other described methods are based on the sound surgical principles of adequate exposure, free vision of the operative field, mobilization of the involved viscera, preservation of the blood supply of the remaining segments, radical excision of the cancer bearing focus with all lymphatic tributaries, and physiological restoration of esophagogastric continuity by a layer suture anastomosis.

CASE REPORTS

CASE 4. J. S., a man aged 46 years, was admitted to Mt. Sinai Hospital on October 1, 1938. He complained of difficulty in swallowing of 7 months' duration. I question the accuracy of this statement. If the carcinoma existed for 7 months, it would have been beyond the operable stage. At least, such has been our experience. The patient had lost only 5 pounds. When admitted to the hospital, he was able to swallow only liquids.

Examination showed a moderately emaciated white male with no abnormal findings except for a few discrete, small, lymph nodes palpable in the left anterior and posterior cervical regions.

Laboratory examinations were all negative. Hemoglobin, 88 per cent; urine, negative. Roentgenographic examination of the esophagus revealed a partially obstructing lesion in its upper third at the level of the arch of the aorta (Fig. 18). Esophagoscopy disclosed an infiltrating new growth on the anterolateral wall about 30 centimeters from the upper incisor teeth. The biopsy specimen revealed squamous cell carcinoma.

On October 10, 1938, a Janeway gastrostomy was performed under local anesthesia. Feedings were commenced on the first postoperative day. The wound healed *per primam*.

On October 20, 1938, resection of the esophagus was performed under avertin, ethylene anesthesia. The technique described in the text was employed. The growth was located between the arch of the aorta and the left main bronchus. It was rather firmly attached to the bronchus. In our experience this location is a particularly bad one, because fixation to the bronchus takes place early and a complete excision of the cancer may not be possible. I would hazard a guess that the recurrence rate will eventually be found highest in those cases in which the original tumor is located at this site.

Considerable difficulty was encountered in separating the tumor from the bronchus. This was finally accomplished without sacrificing any important structures. The esophagus was divided just above the cardia and the distal end was inverted into the stomach with 2 purse-string sutures of silk. The remainder of the organ was freed as far as the root of the neck and pushed into the neck above the supra-aortic mediastinal pleura. The latter structure was now repaired. The infra-aortic mediastinum was left wide open. The chest wound was closed, with the establishment of under water drainage through an intercostal tube. The cervical portion of the operation was completed with the formation of an esophageal fistula opposite the left first rib.

The patient's pulse during the operation, which consumed 3 hours and 5 minutes, varied between 84 and 116. The breathing was regular. A transfusion of 500 cubic centimeters was given during the operation and followed by a continuous intravenous drip of 5 per cent glucose in saline.

Examination of the specimen (Fig. 19) disclosed an infiltrating squamous cell carcinoma with 2 small submucous lymphatic metastases near the growth. It was found that the carcinoma had infiltrated the entire esophageal wall.

After the operation the patient was placed in an oxygen tent where he remained for 7 days. During the first week the pulse varied between 94 and 132, and the temperature between 99 and 101.6 degrees F. The drainage through the intercostal tube rapidly diminished in quantity and finally ceased on the eighth day. The tube was removed a day later. The patient began to swallow liquids through the esophageal fistula on the second day. By the second week, the temperature had reached normal and the patient was allowed out of bed. The thoracic and cervical wounds had healed *per primam*.

Because of the location of the growth and the uncertainty of its complete removal, intensive radiation therapy was started during the third week. During the fifth week the temperature began to rise and reached 104 degrees F. For the next 2 weeks the fever assumed a septic course, ranging between 99 and 103.6 degrees F. Repeated roentgenographic and laboratory examinations gave no clue as to the cause of the fever. For some unexplained reason the temperature finally reached normal and remained so until the patient was discharged.

During the eighth week the patient complained of severe precordial pain radiating down the left arm. Examination of the heart revealed nothing of note. However, the electrocardiogram suggested recent myocardial damage by reason of a more deeply inverted T-2 and T-3 with cove-planing. The cardiologist interpreted these findings as due either to actual myocardial infarction or to inflammatory mediastinitis. For this reason the patient was kept in bed for 1 month.

The rubber esophagus was inserted during the third week and from that time the patient took most of his food by mouth. He was discharged 4 months after operation and had gained 18 pounds (Fig. 20).

The patient was carefully followed after discharge. He remained well until the latter part of July, 1939, and reached his normal weight of 124 pounds. When seen at that time, he called attention to a firm swelling located at the orifice of the esophageal fistula. This measured ½ inch in diameter, was discrete and firm, and seemed to be located in the anterior wall of the esophagus. A biopsy specimen revealed the features of a squamous cell carcinoma similar to the original growth. Intensive radiation therapy was instituted. After 6 weeks the lump was no longer palpable. Recently, the patient entered the hospital complaining of hoarseness and loss of 10 pounds in weight. Examination disclosed a right Horner's syndrome and paralysis of the right vocal cord. Chest roentgenograms have been repeatedly negative. However, it is apparent that there is a recurrence in the superior mediastinum.

CASE 5. E. P., a man of 56 years, referred by Dr. Frank J. McGowan, was admitted to the New York Hospital on March 9, 1939. He complained of dysphagia of 10 weeks' duration. This was accompanied by increasingly severe substernal oppression. The dysphagia became more pronounced until, at the time of admission, he was able to swallow only liquids. He had lost 20 pounds.

The personal history revealed that the patient had been a fireman for over 20 years and had been overcome by smoke on many occasions. Otherwise he had always been in robust health.

Physical examination revealed a very well developed muscular individual, apparently in excellent health. There

were no abnormal findings. The heart and lungs were negative and there was no shock tenderness over the thoracic spine. Blood pressure: systolic, 136; diastolic, 74.

Laboratory examinations were all normal. Roentgenogram of the esophagus showed an obstruction, almost complete, starting about an inch below the aortic arch. Esophagoscopy revealed an obstructing, ulcerated neoplasm located about 34 centimeters from the upper incisor teeth. The biopsy specimen indicated a hornifying squamous cell carcinoma.

On March 14, 1939, a Janeway gastrostomy was performed under local anesthesia. Feedings were started on the next day. The operative wound healed by first intention. There was a weight gain of 3 pounds during the succeeding 12 days.

On March 22, 1939, resection of the esophagus was performed under avertin, ethylene anesthesia. The technique described in the text was employed. The neoplasm was about 2 inches in length and was situated just below the arch of the aorta. It was found to be intimately attached to the right mediastinal pleura. In order to effect removal it was necessary to excise a fairly large portion of the right pleura, thus producing a bilateral pneumothorax. The opening was temporarily packed with gauze. The esophagus was divided above the cardia and the distal end was doubly inverted into the stomach. The organ was then completely freed from its attachments and pushed into the base of the neck after the supra-aortic mediastinal pleura was incised. The latter was then repaired so as to close off the neck from the thoracic cavity. In order to close the opening effectively in the right mediastinal pleura, it was found necessary to suture the left mediastinal pleura. A stab thoracotomy in a subjacent intercostal space completed the thoracic phase of the operation.

The cervical part of the operation was then completed in the usual manner. An esophageal fistula was fashioned over the left second rib anteriorly.

During the operation, which consumed 2 hours and 50 minutes, the pulse varied between 82 and 116 and the systolic pressure between 130 and 110. A transfusion of 500 cubic centimeters was given during the procedure and the patient left the operating table in excellent condition.

The specimen (Fig. 21) consists of a segment of esophagus, measuring 12 centimeters in length and 6.5 centimeters in average circumference. At its mid-point it is narrowed to approximately 2.5 centimeters by a thick, infiltrating tumor which invades the wall. The tumor has an ulcerated surface; the ulcer is linear rather than circular, which gives it a longitudinally excoriated appearance. Two centimeters proximal to this is a nodular whitish mass 15 by 10 millimeters in area, the center of which is also excoriated. The mucosa over this tumor is apparently well preserved. Beneath it is a white tumor mass which extends through the wall. There is no apparent lymphoid connection between the 2 tumors. The mucosa on the opposite side of the main growth shows numerous linear rows of whitish tubercles approximately 1 millimeter in diameter. The outer side of the specimen shows a complete covering of musculature, which on section, in the region of the growth, reveals invasion by tumor tissue. The substance of the tumor and that of the overlying mucosa is very friable. Microscopic examination reveals the features of an epidermoid carcinoma with numerous mitotic figures. The tumor extends through the entire esophageal wall. Sections taken through the smaller growths reveal carcinoma also with tumor cells in the lymphatics.

In the light of subsequent events, a serious error of omission was committed. The right chest should have been aspirated at the completion of the operation to remove the large amount of air trapped in the right pleural cavity. I believe that, if this had been done, the patient would have survived.

On the following day serious respiratory embarrassment developed. The patient was wildly delirious and required large doses of sedative. Only slight improvement was noted after he was placed in an oxygen tent. Physical signs of a complete right pneumothorax were apparent. On chest aspiration, approximately 7,000 cubic centimeters of air was removed. A stab thoracotomy was performed with under-water drainage. The patient seemed to improve for a few hours. However, soon after, he rapidly became comatose and died 40 hours after operation with a terminal temperature of 107.6 degrees F.

Postmortem examination revealed a tension pneumothorax on the right side with atalectasis of the entire right lung. The operative field was clean and the sutured left mediastinal pleura effectively separated the left from the right pleural cavity. In one tracheobronchial lymph node a small metastasis was noted.

CASE 6. J. C., a white male of 60 years, was admitted to the surgical service of Mt. Sinai Hospital on April 19, 1939. His main complaint was difficulty in swallowing food, of 5 weeks' duration. The onset was quite sudden with dysphagia accompanied by aching pain behind the lower end of the sternum. During the succeeding 5 weeks the dysphagia and pain became more pronounced. At the time of admission he had difficulty in swallowing even liquids. There was a weight loss of 12 pounds.

His past history was negative except for excision of a left varicocele 35 years before. He stated that he had been rejected for life insurance 20 years ago because of "heart disease."

Physical examination disclosed a moderately well developed elderly white man with evidence of recent weight loss. There was slight tenderness on firm pressure over the lower end of the sternum adjacent to the fourth costal cartilage. The heart and lungs were negative. Blood pressure: systolic, 130; diastolic, 75.

Laboratory examinations revealed hemoglobin 59 per cent; urine negative. Blood urea 21 milligrams per 100 cubic centimeters, blood sugar, 70 milligrams, Wassermann, negative. Roentgenogram of the esophagus following the ingestion of barium mixture showed the presence of an obstructing lesion just above the cardiac end of the stomach. The neoplasm extended through the cardia for a short distance (Fig. 22). Esophagoscopy revealed a crater-like circular ulcerating neoplasm in the distal esophagus 39 centimeters from the upper incisor teeth. The biopsy specimen showed an infiltrating hornifying squamous cell carcinoma.

The preliminary preparation consisted of a transfusion of 500 cubic centimeters of blood, high caloric feedings, and the administration of sulfanilamide for 3 days before operation.

Operation was performed on April 27, 1939. The technique described in the text was followed. The incision was located in the eighth interspace and the seventh, sixth, and fifth ribs were divided near the spine. The neoplasm was felt in the lower end of the esophagus and involved the distal 2 inches of the organ. It extended through the diaphragm into the cardia for a short distance. It was densely adherent to the diaphragm at the esophageal hiatus. In order to obtain definite information concerning operability, a radial incision was made in the diaphragm from the esophageal hiatus outward. There were no palpable lymph nodes in the gastrohepatic omentum or in the mediastinum. Aside from the firm attachment to the diaphragm, the tumor was considered operable. A radical removal was affected by excising a portion of the diaphragm with the tumor. The stomach was mobilized by ligating

and dividing the gastric artery and the left gastric epiploic vessels. The esophagus was freed from its surrounding attachments as far as the arch of the aorta, and end-to-side suture anastomosis was performed between the stump of the esophagus and the anterior wall of the stomach near the greater curvature; silk was used for both layers. The stomach was pulled upward over the suture line in a sleeve-like manner and anchored with interrupted stitches to the esophageal wall and to the cut edges of the mediastinal pleura in this situation.

In dissecting the tumor from the diaphragm and the lower mediastinum it was found necessary to excise a small section of the right mediastinal pleura, thus producing a bilateral pneumothorax. This opening was closed by suturing the stomach wall to the edges of the right pleural opening.

The diaphragm was now closed in such a way as to prevent constriction of the transposed stomach. To prevent herniation of the stomach into the chest, the edge of the diaphragmatic opening was sutured to the stomach wall. A stab wound thoracotomy for under water tube drainage was made in the subjacent intercostal space. At the completion of the operation the right chest was aspirated and 3,000 cubic centimeters of air was removed.

The patient showed very little evidence of shock during this procedure, which consumed 3½ hours. The pulse varied between 80 and 104, blood pressure between 130 and 110. A transfusion of 500 cubic centimeters of blood was given during the course of the operation. This was followed by a continuous intravenous drip of 5 per cent glucose and saline.

Examination of the specimen showed a squamous cell carcinoma of the esophagus invading the cardia of the stomach. No involved lymph nodes were found (Fig. 23).

After operation the patient was placed immediately in an oxygen tent where he remained for 10 days. He did not swallow for 6 days. In addition to the intravenous drip, concentrated vitamin extracts were administered parenterally. On the first postoperative day the pulse varied between 108 and 126. Temperature was 100.8 degrees F. For the first 6 days the temperature ranged between 99 and 100.4 degrees F. His pulse ranged between 90 and 100. His general condition was excellent. He developed a mild cough with expectoration of small amounts of mucopurulent material. The drainage from the thoracotomy tube, at first bloody, rapidly diminished and finally stopped on the eighth day. The tube was removed on the ninth day. The operative wound healed by primary union. The hemoglobin fell to 55 per cent on the sixth day. He was given several blood transfusions after which the hemoglobin rose to 80 per cent. Small amounts of water were swallowed for the first time on the sixth day. There was no difficulty. On the ninth day signs of a right pleural diffusion developed. Upon aspiration 1,200 cubic centimeters of thin, serosanguinous fluid was withdrawn. There was no re-accumulation. The patient's course, therefore, was uncomplicated. His food intake by mouth was rapidly increased in quantity and quality. On the twenty-third postoperative day barium was given by mouth and roentgenograms of the esophagus and stomach were obtained (Fig. 26). The patient gained weight steadily and had no difficulty in swallowing. He was discharged from the hospital on the thirty-fifth postoperative day in excellent condition (Figs. 24 and 25).

Since discharge from the hospital, the patient has done well. He eats everything but finds that he must masticate his food thoroughly. He has returned to his normal weight.

CASE 7. M. G., a man of 35 years, was admitted to Mt. Sinai Hospital on August 19, 1939. This is the youngest patient with carcinoma of the esophagus that we have encountered in our experience. He complained of dysphagia of 4 weeks' duration. In addition, he stated that approximately 3 months before he began to have pain in the anterior chest region and also in the middle of the back. The difficulty in swallowing became progressively worse until at the time of admission he was able to swallow only liquids. He had lost 35 pounds.

His past history was completely negative. He had always been well and had not undergone any operations.

Physical examination disclosed a well developed and rather well nourished young man who appeared to be in good health. There was no obvious anemia. The heart and lungs were negative. There was no shock tenderness over the thoracic spine.

Laboratory examinations revealed the urine to be negative; hemoglobin, 95 per cent; red blood cells, 5,200,000; normal white blood cell count; Wassermann, negative. Roentgenographic examination of the esophagus disclosed an obstruction beginning just behind the arch of the aorta and extending downward for a distance of approximately 2 inches (Fig. 27). Esophagoscopy showed an ulcerated neoplasm situated on the posterior wall of the esophagus about 30 centimeters from the upper incisor teeth. The biopsy examination revealed squamous cell carcinoma.

On August 21, 1939, a Janeway gastrostomy was performed under local anesthesia. Tube feedings were started the next day. Operative wound healed by first intention. On August 31 radical resection of the esophagus was performed under avertin, ethylene anesthesia. The neoplasm was located between the arch of the aorta and the left main bronchus. It was easily separated from the aorta, but was densely adherent to the bronchus. The entire esophagus was freed and the tumor bearing portion was separated from the surface of the bronchus by sharp dissection. There was some doubt in the operator's mind concerning the complete extirpation of the tumor because of this firm attachment. The esophagus was divided at its lower end and the distal end triply inverted into the stomach with silk. The remainder of the esophagus was pushed up into the base of the neck after an incision was made in the supra-aortic mediastinal pleura. The latter structure was now repaired with interrupted silk stitches in order to close off the pleural cavity from the neck. The mediastinum was left wide open. A stab thoracotomy was made in the subjacent intercostal space for under water tube drainage. The cervical part of the operation was now completed with the establishment of an esophageal fistula opposite the second left rib.

During the course of the operation, which consumed 2 hours and 50 minutes, the patient's pulse varied between 84 and 128. The blood pressure dropped from 130 to 100 during the dissection of the growth from the arch of the aorta. A transfusion of 500 cubic centimeters of blood was given during the operation and was followed by a continuous intravenous drip of 5 per cent glucose in saline. The patient left the operating table in excellent condition.

The specimen (Fig. 28) consists of a resected segment of esophagus which measures 8 centimeters in length and 4 centimeters in width. Beginning about 1 centimeter from one end is an oval-shaped tumor mass which is extensively ulcerated in the central portion. This measures 4.5 centimeters in length and 2 centimeters in width. The edges of this ulcerated tumor are distinctly elevated and firm, and the mucosa covering the edges cannot be moved against the underlying structure. The ulcer base is grayish yellow in color and appears to be quite cellular. The ulcer undermines the edges to a remarkable degree in several areas. The remaining mucosa is grayish, glistening, and grossly not unusual. No lymph nodes can be seen. The microscopic picture is that of an infiltrating, hornifying squamous cell carcinoma.

During the initial 24 hours the patient's general condition remained excellent. On the second day the temperature rose to 104 degrees F. with a pulse rate of 130. The drainage from the intercostal tube was bloody. On the third day the fever reached a lower level, but the respiratory rate rose to 40. Signs of consolidation were elicited over the right lower lobe. The patient was placed in an oxygen tent and sulfapyridine was administered by gastrostomy tube. During the next 36 hours the temperature fell to normal and the patient's general condition was quite satisfactory.

On the seventh day mild respiratory difficulty was noted and the temperature rose to 103.8 degrees F. A bedside roentgenogram of the chest suggested fluid at the left base. There was a leucocytosis of 21,000. The intercostal tube was draining a small quantity of thick serous fluid. Chest aspiration posteriorly and laterally gave negative results. On the tenth day a slight respiratory bulge was noted in the center of the thoracic incision which had healed *per primam*. A probe was inserted at this point and entered a collection of 14 ounces of bloody fluid located in a walled-off portion of the pleural cavity in the vertebral gutter. The opening was enlarged and tube drainage instituted.

Following the evacuation of this fluid, the patient's condition improved rapidly. The temperature fell gradually and the respiratory rate reached normal. The rubber esophagus was inserted on the thirteenth day and all feedings were taken by mouth thereafter.

At the present writing, it is 16 days since operation. The patient's condition is improving rapidly and it is expected that he will be allowed out of bed within the next few days.

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SURVIVAL STATISTICS OF BREAST CANCER

1925 to 1935

WILLIAM H. KRAEMER, M.D., Wilmington, Delaware

IT has long been felt that within recent years certain advancements in clinical and laboratory technique, in surgery, in roentgenography, and in radium therapy warranted the assumption that survivorship percentages of patients treated by these methods would be improved substantially.

The education of the public to the importance of the early diagnosis in malignant diseases as stressed by the American Society for the Control of Cancer, emphasized by the American College of Surgeons, and made possible through the establishment of tumor clinics such as at Jefferson Hospital in 1930, where collective diagnosis by a trained staff becomes a reality, should also support this conclusion.

This survey was conceived for the purpose of determining whether the anticipated results could be substantiated by an analysis of actual records of a general hospital with this exception —the equipment and staff of Jefferson are those of a teaching institution, and for the previously discussed reasons this 10 year period from January 1, 1925, to December 31, 1934, was selected.

For comparison this 10 year period was divided into two 5 year periods; in the first period, that of 1925 to 1929, there were 167 cases, and in the second period, 1930 to 1934, there were 266, or a total of 433. Of these 433 cases, 16 patients died from other causes, which left a total of 417. The survivorship percentage at the end of the fifth year for the 1925 to 1929 cases was 39.75, and for the 1930 to 1934 cases it was 34.89 per cent. At the end of 9 years, the survivorship percentage for the 1925 to 1929 cases was 22 per cent, as against 26 per cent for the 1930 to 1934 group.

While in this report only cancer of the breast is being presented, the survey eventually will include all types and all sites of cancer, both ward and private, young and old, early and advanced.

This report has already revealed to us that the only method with which to evaluate the results of all cancer therapy is through a complete history of the case at the time of treatment and a follow-up service thereafter as long as the patient is alive.

The follow-up services have always been difficult and expensive due to a constant shifting among the city and suburban population. These cases were followed up through the family physician and specialist who were first consulted, the Social Service Department of the hospital, and finally by the Retail Credit Company of Atlanta, Georgia. The latter was most successful in tracing cases in distant parts of the United States, Canada, South America, and Europe.

Recognizing the complexity of this kind of statistical survey, we consulted Dr. Raymond Pearl, director of the Department of Biology, School of Hygiene and Public Health of Johns Hopkins University, and his associates, Dr. Antonio Ciocco, Dr. B. Aubrey Schneider, and Joseph F. Kish who were given the responsibility for the construction of the survivorship graphs and charts which are being presented here.

In evaluating these charts the adjustment for the age factor is taken from the U. S. Life Tables of 1930 (white females in the continental U. S.) for the 1930 to 1934 group, and for the 1925 to 1929 group the life expectancy values were obtained by interpolating between the 1920 and the

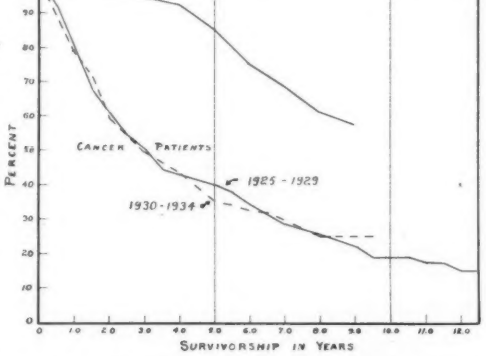

Chart 1. U. S. general population 1930 life table (female)

From the Department of Neoplastic Diseases, Elizabeth Storck Kraemer Memorial Fund sponsored by Pierre S. and Lammot du Pont, Jefferson Medical College Hospital.

Presented in the Cancer Symposium before the Clinical Congress of the American College of Surgeons, Philadelphia, October 16–20, 1939.

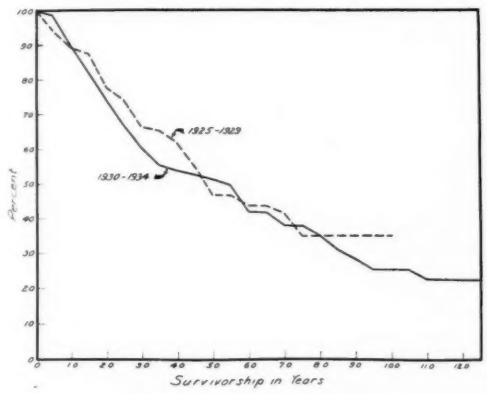

Chart 2. No metastases.

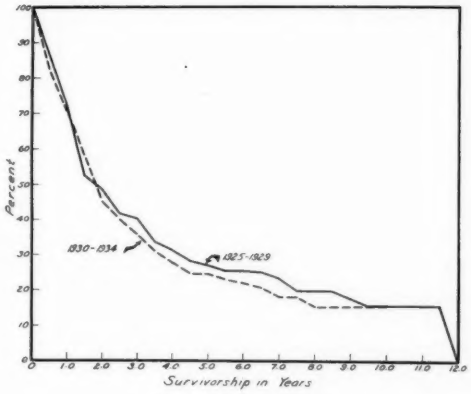

Chart 3. Metastases.

1930 life tables. The manner of calculation was as follows:

Age in years	Life expectancy per 100,000
30 to 31	87,972
31 to 32	87,644
32 to 33	87,308
33 to 34	86,964
34 to 35	86,611

This means that of 100,000 white females born alive, 87,972 are expected to survive to exactly 30 years of age, 87,644 thirty-first year, etc. Thus, a white female, 30 years of age, when nothing is known about the condition of her health, has a 87,644/87,972 probability of surviving exactly 1 year, a 87,308/87,972 of surviving exactly 2 years, etc. In a similar manner, the probabilities for each of the 417 cancer of the breast patients of surviving 1 year, 2 years, up to and including 13 years were calculated. For example, there are 57 cases in the "no metastasis, with operation and x-ray" division of the 1930 to 1934 group, for which the actual age and survival is known. Now a survivorship curve for 57 white females having the identical age distribution of each of the 57 cancerous patients is plotted, based on their probability of surviving exactly 1 year, 2 years, 3 years, etc. The percentage deviation of

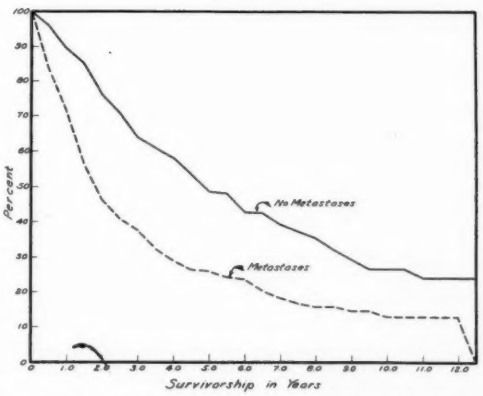

Chart 4. Combined data on patients with and without metastases for 1925 to 1929 and 1930 to 1934.

the actual observed survivorships of the 57 cancerous females at each year from this "expected" survivorship is then plotted.

When a curve coincides with the 0 per cent line or curve as in Chart 1, it means that that group is dying off at the same rate as a group of the same age composition selected from the general population of white females. Coincidence with the

TABLE I.—TOTAL DATA FOR SURVIVORSHIP

Survey grouping	Total number of cases	Total number living at end of 5th year	Per cent of total number living end of 5th year	Dead at end of 5th year	Per cent of deaths during 5th year	Deaths other than cancer	Survivorship per cent calculated (see example)
Normal	417	352	84.41	65	7.90		85.23
1925 to 29	166	65	39.15	100	7.04	1	39.75
1930 to 34	251	73	29.08	163	18.92	15	34.89

TABLE II.—SURVIVORSHIP OF PATIENTS WITH OR WITHOUT METASTASIS

Survey grouping	Cases Total No.	Total number living at end of 5th year	Per cent of total number living	Deaths at end of 5th year	Per cent of deaths July-Dec. inclusive 5th year	Deaths other than cancer	Survivorship per cent according to graph
1925 to 1929 Metastases	74	20	27.02	54	4.76	0	27.04
Non-metastases	78	39	50.00	38	2.44	1	51.29
1930 to 1934 Metastases	144	29	20.13	108	8	7	24.98
Non-metastases	104	41	39.42	55	14.81	8	46.74
1925 to 1934 Metastases	218	49	22.47	162	1.81	7	25.69
Non-metastases	182	80	43.95	93	9.47	9	48.76

100 per cent ordinate means that the group has died before the end of 1 year. The closer a curve approaches the 0 per cent line or curve, the more nearly the members of that group are dying off as one would expect a similar number of females of the same age composition from the general population to do.

In Table I, the total data for the survivorship for 1925 to 1929 and 1930 to 1934 groups compared with a normal U. S. Life Table group of the same age composition, appear, from which Chart 1 is plotted.

To determine the survivorship per cent for any desired period, obtain from the appropriate table or curve the percentage of deaths during this period and subtract this value from 100, thus finding the per cent of persons who were alive at the start and close of this period. Then from the appropriate curve obtain the survivorship per cent for the beginning of the period under discussion, and multiply it by the per cent of persons who were alive at the start and close of this desired period. For example, to determine the survivorship per cent of the normal group in Table I for the five year period, refer to Chart 1. From the observed values for the normal group, the percentage of expected deaths during the fifth year can be found by subtracting the percentage surviving at the end of the fifth year from the percentage surviving at the end of the fourth year, which is 7.90 per cent. Then subtract this figure (7.90) from 100 to obtain the per cent of all those who started the period alive and are still living at its conclusion. Then the percentage survivorship for the fifth year is obtained by multiplying the remainder just obtained (92.10) by the percentage surviving at

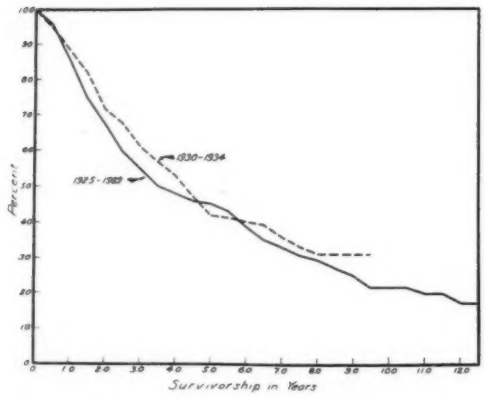

Chart 5. All patients operated upon.

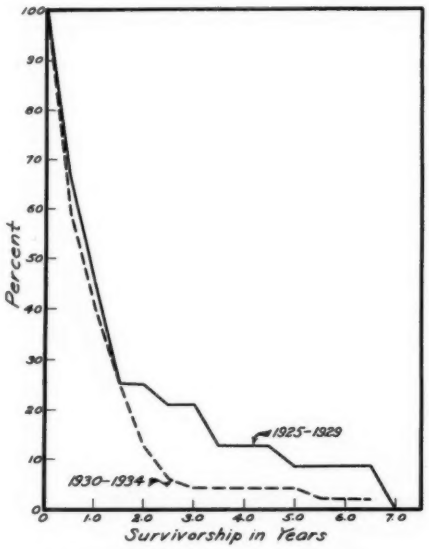

Chart 6. All patients not operated upon.

TABLE III.—SURVIVORSHIP DATA ON PATIENTS OPERATED AND NON-OPERATED UPON

Survey grouping	Cases Total No.	Total number living at end of 5th year	Per cent of total number living	Deaths at end of 5th year	Per cent of deaths July-Dec. inclusive 5th year	Deaths other than cancer	Survivorship per cent according to graph
1925 to 1929 Operation	142	63	44.36	78	1.54	1	45.08
Non-operation	24	2	8.33	22	53.33	0	8.33
1930 to 1934 Operation	200	71	35.50	114	8.99	15	42.78
Non-operation	47	2	4.25	45	0	0	4.26
1925 to 1934 Operation	342	134	39.18	192	5.85	16	43.77
Non-operation	71	4	5.63	67	20.00	0	5.63

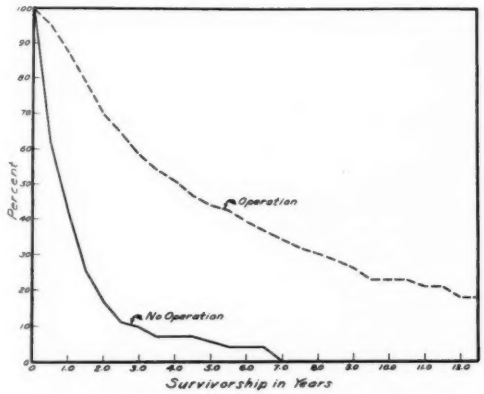

Chart 7. Combined data on patients operated upon and not operated upon for 1925 to 1929 and 1930 to 1934.

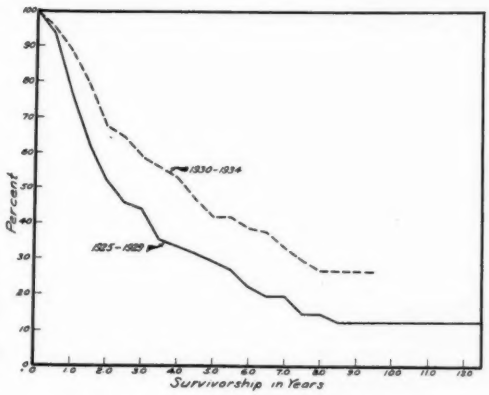

Chart 8. Operation with x-ray.

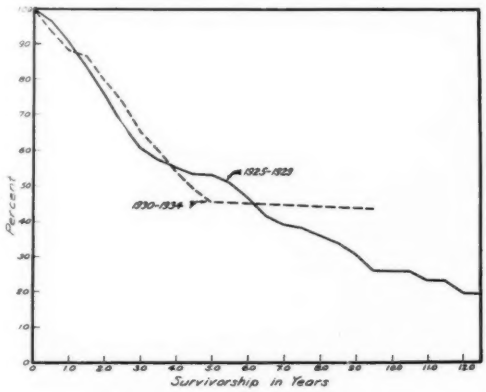

Chart 9. Operation without x-ray.

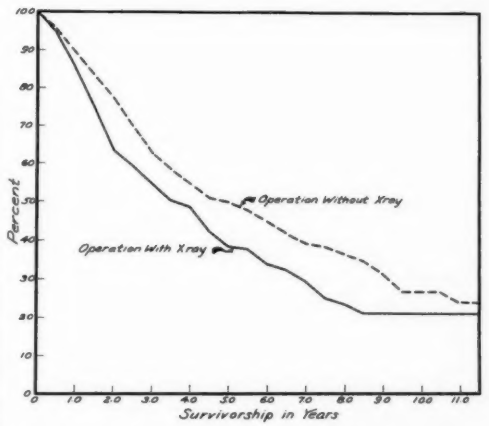

Chart 10. Combined data on patients operated upon with and without x-ray during 1925 to 1929 and 1930 to 1934.

TABLE IV.—SURVIVORSHIP DATA FOR PATIENTS OPERATED UPON TREATED OR NOT TREATED WITH ROENTGENOTHERAPY

Survey grouping	Cases Total No.	Total number living at end of 5th year	Per cent of total number living	Deaths at end of 5th year	Per cent of deaths July-Dec. inclusive 5th year	Deaths other than cancer	Survivorship per cent according to graph
1925 to 1929 Operation with x-ray	48	13	27.08	34	6.67	1	29.17
Operation without x-ray	94	50	53.19	44	0	0	53.21
1930 to 1934 Operation with x-ray	131	45	34.35	76	10.71	10	41.58
Operation without x-ray	69	26	37.69	38	6.06	5	45.62
1925 to 1934 Operation with x-ray	179	58	32.40	110	9.85	11	38.28
Operation without x-ray	163	76	46.62	82	2.41	5	49.71

TABLE V.—SURVIVORSHIP AFTER OPERATION OR TREATMENT

Survey grouping	Number of cases	Metastases	Operation	X-ray	Actual number expected to survive 5 years	Number that did survive 5 years	Difference between expected and actual survivorship	Per cent that died of those expected to live
1925 to 1929 Curve 1	24	yes	yes	yes	21.43	7	14.43	67.33
Curve 2	12	yes	none	yes	10.91	0	10.91	100.00
Curve 3	20	none	yes	yes	18.11	6	12.11	66.85
Curve 4	32	yes	yes	none	27.87	12	15.87	56.94
Curve 5	56	none	yes	none	49.28	32	17.28	35.07
1930 to 1934 Curve 1	72	yes	yes	yes	62.14	18	44.14	71.03
Curve 2	40	yes	none	yes	36.00	1	35.00	97.22
Curve 3	105	yes	yes		89.73	29	60.73	67.68
Curve 4	57	none	yes	yes	46.77	27	19.77	42.27
Curve 5	33	yes	yes	none	27.59	11	16.59	60.14
Curve 6	90	none	yes		74.13	41	33.13	44.69
Curve 7	33	none	yes	none	27.36	14	13.36	48.83

the beginning of the fifth year as obtained from the curve (0.9254). This gives the desired product, 85.23 per cent. The same value would be obtained if a 6 month period, instead of a 12 month period, was used, the method of calculation being identical; (100–3.95) 0.8874=85.23 per cent.

In Table II will be found the data for plotting graphs in Charts 2, 3, and 4 which show the survivorship of patients having metastasis or no metastasis at the time of entrance to the hospital.

The data for plotting graphs in Charts 5, 6, and 7 will be found in Table III and they show the survivorship for operation and non-operation during both 5 year periods and the 10 year period.

Table IV contains the data for the survivorship for all patients operated upon who were or were not treated with x-ray during both 5 year periods and the 10 year period.

The data for plotting Charts 11 and 12 will be found in Table V and show the years of survivorship after operation or treatment for both 5 year periods. The per cent who died of those expected to live is found by the following formula: $\frac{100 \times \text{difference}}{\text{expected survivors}}$

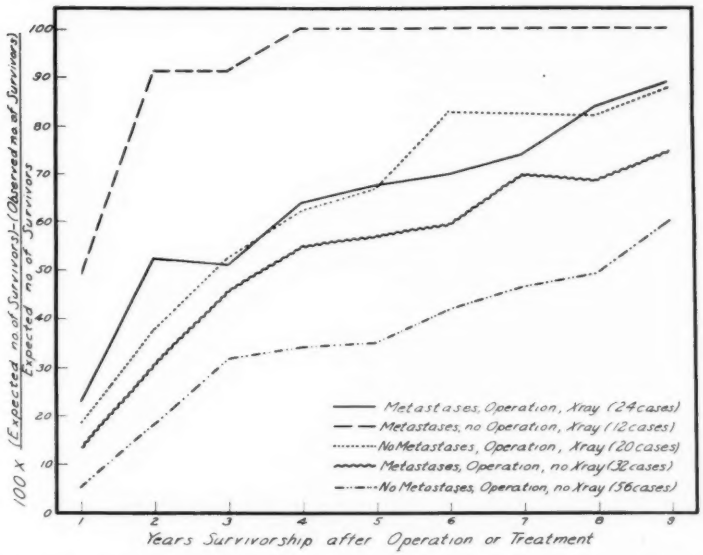
100 x (Expected no of Survivors)-(Observed no of Survivors) / Expected no of Survivors
Metastases, Operation, Xray (24 cases)
Metastases, no Operation, Xray (12 cases)
No Metastases, Operation, Xray (20 cases)
Metastases, Operation, no Xray (32 cases)
No Metastases, Operation, no Xray (56 cases)
Years Survivorship after Operation or Treatment

Chart 11. Years of survivorship after operation or treatment for 1925 to 1929 group.

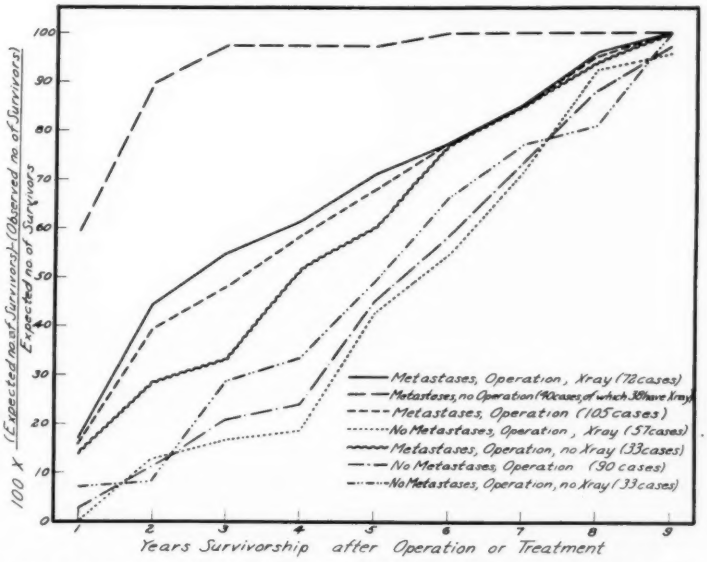
100 x (Expected no of Survivors)-(Observed no of Survivors) / Expected no of Survivors
Metastases, Operation, Xray (72 cases)
Metastases, no Operation (40 cases, of which 38 have Xray)
Metastases, Operation (105 cases)
No Metastases, Operation, Xray (57 cases)
Metastases, Operation, no Xray (33 cases)
No Metastases, Operation (90 cases)
No Metastases, Operation, no Xray (33 cases)
Years Survivorship after Operation or Treatment

Chart 12. Years of survivorship after operation or treatment for 1930 to 1934 group.

Chart 13 shows the years of survivorships after operation or treatment, the data for which will be found in Table VI.

The unadjusted curve would make it seem that the 1925 to 1929 group is surviving better than the 1930 to 1934 group. This is because in the

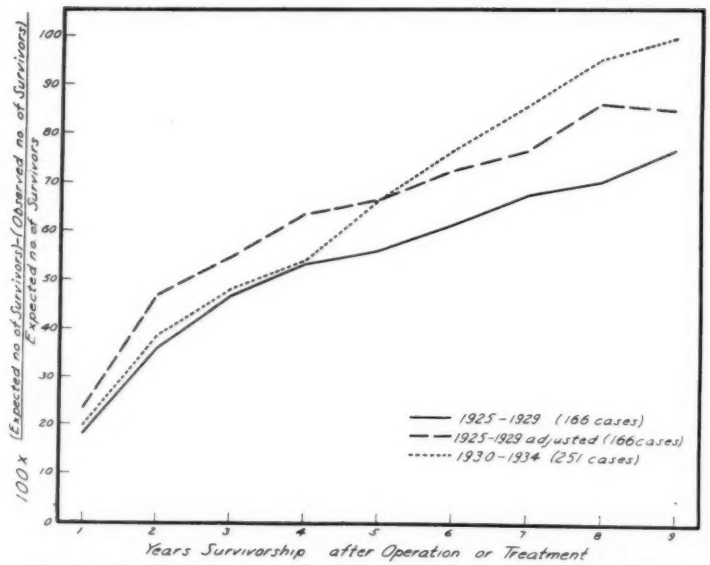

Chart 13. Combined data on survivorship after operation or treatment for 1925 to 1929 and 1930 to 1934 groups.

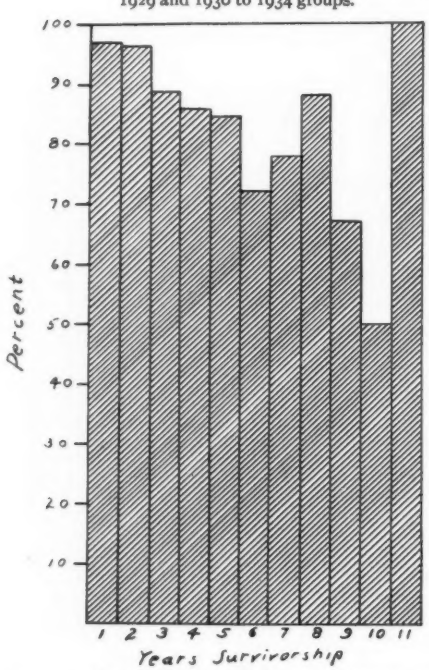

Chart 14. Combined data. Blocked area shows cancer mortality; clear area, mortality from other causes.

1925 to 1929 group, 56 cases fell by chance into the best surviving group (no metastasis, operation, no x-ray) and only a few into the worst surviving group (metastasis, no operation, x-ray). This would make comparison unfair. Therefore, the 166 cases were reapportioned so that each surviving group was in the same proportion as that same group in the 1930 to 1934 period. This adjustment makes the two groups comparable. Moreover, as only 7 cases have not been traced as living or dead in the 1925 to 1929 group through all of 9 years, and 11 cases in the 1930 to 1934 group, with 63 cases in the 1930 to 1934 group not having passed through the 9 year period of observation, it can be seen that if these cases were traced, the 1925 to 1929 curve would change but little, while the 1930 to 1934 curve would be pulled down to the 0 per cent line by an unknown amount.

It appears from Chart 12 that metastasis cases, with or without x-ray, do not survive as well as the non-metastasis cases having x-ray or not. The no operation, with metastasis, with x-ray cases are the poorest survivors in the 1925 to 1929 and the 1930 to 1934 groups. The curves on Charts 11 and 12 had best not be compared pair by pair (for reasons already discussed).

In comparing the total 1925 to 1929 adjusted curve on Chart 13 with the 1930 to 1934 curve on the same chart, while it is probable that the 1930

TABLE VI.—SURVIVORSHIPS AFTER OPERATION OR TREATMENT

Survey grouping	Number of cases	Actual number expected to survive 5 years	Number that did survive 5 years	Difference between expected and actual survivorship	Per cent that died of those expected to live
1925 to 1929	166	146.51	65	81.51	55.63
1930 to 1934	251	213.93	73	140.93	65.87
1925 to 1929 Adjusted	166	147.98	50.2	97.78	66.08

to 1934 group is surviving better, the difference between the two at best would not be large.

From the slope of the normal U. S. Life Table curve in Chart 1 it appears that after approximately 4 years the cancer patients are dying off at the same rate as the non-cancerous, but this is to be expected since most of the patients with rapid malignant lesions have already died, the greater majority of the remaining cases are made up of inactive and slowly growing tumors, and a large number of this group of patients have attained an age beyond the normal life expectancy for females according to the U. S. Life Tables for this period, resulting in a survival curve similar to normals of the same age composition. For example, when the surviving patients attain the age of 70 their life expectancy curve would be similar to the curve of normal individuals of the same age composition since they have already exceeded the normal life expectancy of their group in spite of their malignant condition.

The relationship between the groups in which patients died from cancer and the group in which patients died from causes other than cancer is shown in Chart 14. The clear area above the blocking shows the patients who died from other causes definitely proved not to be cancer. In order to evaluate life expectancy in malignant cases it is necessary to follow the patients until death since many patients die from cancer after the fifth year and not from causes other than this disease, as shown in Chart 14.

SUMMARY AND RESULTS

The most striking facts revealed by these charts is that no matter what sort of treatment or combination of treatments are given to patients having cancer of the breast, patients in *every* group die off much more rapidly than one would expect women of their ages to do, if the United States Life Tables are used as a standard of comparison.

No important differences exist in the survivorship data between the cases in the 1925 to 1929 period and the cases in the 1930 to 1934 period as shown in Chart 13.

The survivorship is significantly less at all stages for the patients showing metastasis on admission than for those patients showing no metastasis.

The survivorship is significantly and increasingly lower for those patients *not* operated upon than for those that received operation.

The survivorship after operation is significantly *lower* for the cases in which roentgenotherapy was used to supplement operation than for cases in which no such treatment was used. This difference, however, is less in the 1930 to 1934 cases than in the 1925 to 1929, a fact which indicates an improvement in the "x-ray with operation" technique in the latter period. This is due in a great part to (1) the selection of cases, since a great number of patients in the surgical group, who had good prognoses were not exposed to roentgenotherapy and practically all those with a poor prognoses were treated by deep roentgen-rays; and (2) in the 1925 to 1929 group, 56 cases fell by chance into the best surviving group (no metastasis, operation, no x-ray) and only a few into the worst surviving group (metastasis, no operation, x-ray), which would make comparison unfair.

SYMPOSIUM: UROLOGY

UROLOGICAL ASPECTS OF HYPERTENSION

DAVID W. MacKENZIE, M.D., F.A.C.S., F.R.C.S. (C.), and
MAGNUS I. SENG, M.D., F.A.C.S., F.R.C.S., (C.),
Montreal, Canada

TODAY the medical profession is acutely alive to the challenge of hypertension. The internist, surgeon, neurologist, ophthalmologist, and urologist are busily engaged in tracking down the causes of this scourge of mankind. The problem of human so called "essential" hypertension, which means sustained elevation of blood pressure without known or at least demonstrable cause, is being faced resolutely; and it is certainly not beyond reasonable expectation that its source will ultimately be made clear.

Even though the causes of this condition are not known, or at least are surmised only vaguely, relief of some of its more distressing effects is already in the hands of the surgeon.

Secondary hypertension or that caused by some known condition or disease, on the other hand, becomes by that very fact more amenable to relief by either medical measures or surgical attack. It has long been recognized that the kidney may be the organ at fault, as it is known that secondary hypertension occurs more frequently in association with disease or derangement of this organ than with that of any other organs. Richard Bright, in 1836, even before the days of blood pressure estimation, was the first to note the relation of renal disease to hypertension.

In 1872, Gull and Sutton demonstrated widespread organic disease of the smallest arteries and capillaries of the kidney, and seriously considered those changes as the primary cause of the increased peripheral resistance, hypertension, and cardiac hypertrophy.

Since that time the literature has been crowded with clinical and experimental evidence of the rôle the kidney plays in the production of hypertension.

CAUSE OF SECONDARY HYPERTENSION

From the urologist's viewpoint the causes of secondary hypertension may be put into 3 main categories or classifications: (1) Intrinsic disease of the kidney; (2) obstructive disease or conditions involving the upper or lower urinary tract; and (3) the adrenal gland. Intrinsic diseases of the kidney are glomerulonephritis, pyelonephritis, congenital polycystic kidneys, and sclerosis of renal arteries and arterioles, or the so called renal ischemia. Urinary obstruction consists of prostatism and other obstructive and infective conditions of the upper and lower urinary tract. In the adrenal gland we encounter adrenal pheochromocytoma.

Glomerulonephritis and pyelonephritis. In his search for the cause of hypertension the urologist must always bear in mind parenchymal kidney disease and its sometimes close resemblance to chronic pyelonephritis. That organic arteriolar disease of the kidneys, glomerulonephritis, may be the cause of hypertension is an old belief of the medical profession, and the literature abounds with proof that it is so.

In 1930, Bell and Pedersen, in an article discussing the cause of hypertension, noted the fact that up to that time no cases of pyelonephritis had been reported as the cause of hypertension. Longcope and Winkenwerder (26), in 1933, drew attention to the occasional patient with supposed chronic nephritis who died with uremia and showed at autopsy to have in reality a bilateral pyelonephritis, contracted kidneys, and irregularly dilated renal pelves. They report 9 such cases, in 5 of which there was hypertension. The authors did not, however, lay emphasis on the pyelonephritic disease as the cause of the hypertension.

In 1937, Longcope (25) contributed an excellent article on the origin of chronic bilateral pyelonephritis and its association with hypertension. Of the 22 cases he reports, 12 showed hypertension, which usually came on in the later stages of the disease and combined with chronic renal insufficiency. He suggests that the failing renal function is not necessarily a factor in producing

From the Department of Urology, Royal Victoria Hospital.
Presented in the Urology Symposium before the Clinical Congress of the American College of Surgeons, Philadelphia, October 16–20, 1939.

the hypertension, but that arteriolar disease is very suggestively so, because the hypertension is combined with hemorrhagic retinitis and arteriolar lesions of the fundus in a large percentage of the cases.

In the same year A. M. Butler reported 15 cases of pyelonephritis in children, 8 of whom had hypertension averaging 190 millimeters of mercury systolic, and 140 millimeters of mercury diastolic. Butler believes that clinical evidence also demonstrates that hypertension is sometimes associated with pyelonephritis before there is an appreciable diminution in renal function. And he further states that the hypertension, which is secondary to a unilateral pyelonephritis, may disappear after nephrectomy of the involved kidney. He reports 2 cases of unilateral pyelonephritis associated with hypertension, in each of which the hypertension disappeared after nephrectomy of the diseased kidney. While these are among the first such cases to appear in the literature, urologists are now very much alive to the possible association of unilateral kidney disease with hypertension; and the literature already reflects that fact.

In July, 1939, D. W. McIntyre reported a case of unilateral chronic pyelonephritis with arterial hypertension in a young man apparently cured by nephrectomy. He mentions 2 other such cases improved by nephrectomy.

Crabtree and Prien in a recent article, read at the May, 1939, meeting of the American Urological Association, mention the apparent infrequency of reported cases of hypertension in unilateral infections of the kidney as recently as a year previously; but they note that since the subject has become current they themselves know of 11 other local, unreported cases. The authors in this very excellent article, "The Nature of the Renal Injury in Acute and Chronic Colon Bacillus Pyelonephritis in Relation to Hypertension," observe that the data on which is based the condemnation of the pyelonephritis as a factor in the production of hypertension have been observed almost entirely in chronic late, and terminal conditions. They exhort urologists to review their acute pyelonephritis cases as to the cardiovascular systems and hypertension, to study carefully the early pathology, and to note evidence of vascular damage whenever possible in order to determine similarity with known factors concerned in the production of experimental hypertension, and also to observe what types of cases are prone to hypertension.

Crabtree and Prien give a timely warning to urologists against rash surgery in following words:

"The experimental and clinical evidence which is now available is inadequate to place the subject of hypertension on a surgical basis. A hasty rush to attempt surgical relief of hypertension can but result in harm until further facts have been collected and their significance translated into clinical terms. There is at present nothing to indicate whether it is the initial injury from the initial infection, a continuous injury associated with continuous destruction of renal cells of the kidney, a renal injury which sets in motion, through renal deficiency, a process of renal destruction through unexcreted waste products, or, a deranged physiology in poorly nourished renal cells, which is the potent factor in hypertension. Until these factors are sorted and further data supplied, surgery for hypertension must remain in the realm of experimental operations."

Congenital polycystic kidneys. The association of hypertension with the so called congenital polycystic kidney is common knowledge. The condition may be overlooked for a long time until an acute hematuria or renal or ureteral colic directs attention to the urinary tract, at which time the bilaterally, cystically enlarged kidneys are found. It resembles chronic glomerulonephritis, but its victims frequently live longer than the nephritics even though they carry a marked blood chemistry concentration and low phenosulfonphthalein output for years. Approximately 45 per cent of a series of 33 cases of polycystic kidneys reported from our service by Hawthorne and Rauscher (19) showed hypertension. Fishberg puts the percentage between 65 and 75; this high figure is shown in cases usually with marked advanced, renal parenchymal destruction.

Sclerosis of renal arteries and arterioles, so called renal ischemia. The experiments of Goldblatt and his co-workers in the production of experimental hypertension by the induction of renal ischemia are of exceptional interest to urologists and are of great significance to them clinically. These workers produced renal ischemia in dogs and monkeys by means of a special clamp applied to the renal arteries, and immediately an elevation of systolic and diastolic peripheral blood pressure was caused which lasted for a month or more, and in some instances even over a period of 5 years. Goldblatt proved by various experiments that the ischemic kidneys are in some way directly responsible for the development of the experimental hypertension. Perhaps the most striking of these is that if one kidney is transplanted in the neck or inguinal region, and the other kidney is removed, constriction of the arterial blood supply of the transplanted kidney results in the development of hypertension.

Goldblatt states that there are two known mechanisms of development of experimental hypertension induced by renal ischemia: (1) A nervous reflex from the ischemic kidneys which

affects the general vasomotor apparatus; (2) a humoral mechanism initiated by the ischemic kidneys caused by an accumulation in the blood of a substance which acts directly or indirectly to constrict the peripheral vessels.

Goldblatt's experiments failed to establish the nervous reflex as the mechanism responsible for the increased peripheral resistance, but they did tend to show that a humoral mechanism was the cause of the vasoconstriction and the consequent hypertension. Since the publication of his work a number of clinical instances which tend to substantiate the experimental work have appeared in the literature. In 1938, Leadbetter and Burklund reported a case of sustained hypertension caused by disturbance of the arterial circulation of an ectopic right kidney in a colored boy of 5½ years of age. There was no pyelonephritis or coarctation of the aorta. Nephrectomy relieved the hypertension. Pathological examination of the removed kidney showed the lumen of the renal artery reduced to a mere crescentic slit by a mass of smooth muscle tissue—an anomaly of the renal artery.

In 1938, in an article published simultaneously with that of Leadbetter and Burklund, Boyd and Lewis reported a case of arterial hypertension relieved by nephrectomy. In their case Boyd and Lewis thought that the hypertension was caused by an adrenal tumor. Both adrenals and kidneys were explored and a right nephrectomy was done on what appeared grossly to be a tumor of the kidney. Section revealed an infarction of the upper half of the anterior surface of the kidney with a marked thickening of the arterial walls of the renal pedicle.

Mulholland, in an article at present in the process of publication, calls attention to the increased recording of cases of renal artery thrombosis, and mentions 11 such cases reported by Weltz. He brings out the fact that the condition is most often mistaken for some acute intra-abdominal condition, and that early recognition might quite likely prevent the advent of hypertension. Also, in 1938, Freeman and Hartley reported hypertension in a patient with a solitary ischemic kidney. The patient died and necropsy showed an atheromatous plaque partially occluding the lumen of the artery of the solitary kidney.

It is quite evident from the above citations that pathological conditions of the renal arteries causing hypertension have been in most instances accidental findings, and that diagnosis, except for perhaps thrombosis of the renal artery, offers many difficulties and can in the main be only conjectured.

Urinary obstruction. Obstructive conditions of the urinary tract have long been known to be accompanied at times by elevation of the blood pressure and changes in the heart. It is generally recognized that relief of the obstruction results in a lowering of the peripheral vascular tension.

In 1920 and 1923, O'Connor observed a fall of blood pressure in 74 hypertensive urinary obstruction cases following relief of obstruction.

One of us (33) in 1931, also showed a marked fall in blood pressure following drainage in 128 cases of prostatism with hypertension.

The definite rôle played by urological conditions in hypertension has recently been shown by Maher and Wosika. They reviewed 600 cases of hypertensive cardiac disease and found 101 patients, or 16.8 per cent, with urological lesions; whereas only 4.34 per cent of the series were found due to parenchymal renal disease, the commonly accepted cause of hypertension. The basic lesions were those of obstruction, infection, or a combination of both; the obstruction was predominantly in the lower urinary tract. In the males they were principally prostatism. Maher and Wosika believe that hypertension is associated with urological pathology more often than is ordinarily believed, and that investigation of the urinary tract is indicated in hypertension of unknown origin.

Pheochromocytoma of the adrenal. In the urologist's search for the cause of hypertension, new-growth or other changes in the medulla of the adrenal gland must be considered. Certainly no more interesting problem falls to his lot.

Recognition of the train of symptoms of paroxysmal hypertension is comparatively recent in medical history. Labbe and co-workers gave the first clear picture in 1922. Since that time the subject has been thoroughly gone into by such investigators as Belt and Powell, and Edward in the American, Gaertner in the German, and Donzelot in the French, literatures. In 1938, one of us (27) with McEachern reviewed the literature then extant, reported a case in detail, and carefully tabulated 20 cases reported in the literature in which patients had been operated upon, including our own successful case.

METHODS OF DIAGNOSIS, RENAL PHYSIOLOGY, TREATMENT

The diagnosis of those conditions of the urinary tract and the adrenal gland associated with hypertension may offer some difficulty to the urologist, mainly in arriving at an accurate estimation of the localization and extent of the lesion rather than the type of the lesion concerned. It should

not be necessary to insist that a carefully taken history is of prime importance. It must not be forgotten that aside from the so called urological symptoms common to pathological conditions of the urinary tract, the general complaints and symptoms are to be thoroughly developed. A complete physical examination to include blood pressure readings taken several times daily at stated intervals to determine the stability of the hypertension, electrocardiographic studies, ophthalmological investigation of the fundus and visual fields, and finally a searching, urological examination should all be carefully performed.

The urological examination must envisage a careful estimation of the renal function by such tests as the phthalein, Mosenthal, urea clearance or concentration tests, and the usual blood chemistry estimations; and it is only after one has obtained data on the functional capacity of the kidney, that intravenous urography or retrograde pyelography is permissible. There is no question in our minds but that the media used in these two latter procedures may in certain instances be definitely irritating to the kidney itself and to the remainder of the urinary tract.

The clinical pictures of those urological conditions considered to be accompanied sometimes by hypertension, are now well defined and readily recognized. The real problem for the urologist is to determine whether or not the lesion is unilateral, and if unilateral, what the extent of such involvement is. This involves an accurate estimation of the separate functional capacity of each kidney. At the present time the ordinary phthalein and indigocarmine tests used in the differential determination of unilateral disease lack preciseness. Physiologists are coming to our aid and already newer methods of determining kidney physiology have been devised. Homer W. Smith, in a recent publication, reviews these new aspects of renal physiology. He shows that besides the known processes of filtration and re-absorption, a third process has been established, namely, the process of tubular excretion by which the tubular cells remove certain substances from the blood and deliver them directly into the tubular urine. It is now known that those substances universally used by urologists, phenosulfonphthalein and the organic iodine compounds, diodrast, hippuran and iopax, are eliminated by the process of tubular excretion.

Smith pays tribute to the debt that renal physiology owes to urology for the introduction of these products and says:

"It has in the first instance, been possible by the use of diodrast to devise methods for measuring the physiologically effective rate of renal blood flow in man over prolonged intervals of time, the requisite data being only the concentration of diodrast in the blood, and the quantity of diodrast excreted per minute. In the second instance, it has been possible to devise methods for measuring the total quantity of intact tubular tissue in the kidneys (tubular excretory mass), the essential operation being the measurement of the rate of excretion of diodrast when the tubules are saturated with this compound and hence excreting it at a maximal rate. The measurement of effective renal blood flow and of the tubular excretory mass would seem to hold considerable promise in the exploration of normal renal function and the nature and cause of renal disease."

Smith continues to discuss the various clearance methods by means of which the filtration rate, the renal blood flow, and the total tubular excretory mass of the normal human kidney are measured. He feels that the ability to measure the renal blood flow has a special aptness in view of the work of Goldblatt on renal ischemia.

While these tests, as constituted at present, are not as simple as might be desired there is great hope that greater simplification and, therefore, more widespread use will not long be delayed.

We, therefore, emphasize careful study of the hypertensive case, as exact an estimation of the extent of the lesion as possible, and the adding to the admonition of Crabtree and Prien whatever weight our word may have, that urologists must not hastily or indiscriminately resort to surgery in the hypertensive patient.

At the present writing nephrectomy is the common surgical procedure used in combating hypertension associated with unilateral kidney disease. It is certainly not impossible that newer and finer methods of estimation of kidney physiology allowing the early diagnosis of renal vascular pathology will be perfected and will result in the devising and utilizing of more conservative surgery.

Goldblatt in his work on experimental hypertension observed that in those animals in which hypertension had returned to a lower level after the clamping of the renal artery, it was due either to an inadequate clamping of the artery, or the development of an effective accessory circulation by way of the ureteral and capsular vessels. He noted that if the kidney were decapsulated before clamping the artery, the accessory circulation became pronounced and interfered with the development of hypertension. Further, animals have survived for years by means of the accessory circulation when both renal arteries have gradually been closed off completely. Goldblatt himself suggests that in the clinical application of the production of an adequate accessory circulation, it would be more apt and effective in those cases in which the hypertension is due to sclerosis of the main renal arteries or the larger branches.

Paunz, in 1930, demonstrated that in the dog a new blood supply to the kidney can be established by omentopexy; as likewise did Professor Heymans. Abrami, Iselin, and Robert-Wallach, in January, 1939, reported unilateral nephro-omentopexy in 2 cases of hypertension of renal origin. In both cases the blood pressure was lowered only temporarily, but subjectively each patient was benefited. While the authors feel they have failed in these particular instances, they believe that the method holds promise.

Likewise, Homer Smith in the article quoted above mentions 2 hypertensive patients on whom renal omentopexy was performed without having convincing evidence of improvement of the renal function.

In the search for the cause of the hypertension in the adrenal gland a number of well known procedures are used, namely: (1) The flat plain film showing both diaphragms with soft tissue shadows above the kidneys or unusual distance between diaphragm and upper pole of kidney. (2) Intravenous urogram and retrograde pyelogram to visualize displacement of the kidney or distortion of it by an adrenal new growth. (3) Perirenal insufflation of air to visualize kidney and adrenal. (4) Surgical exploration.

It will nearly always be found necessary to use all methods to come to definite conclusions about the given case.

The third procedure, air infiltration, was first suggested by Carelli in 1921, and modified by Cahill in 1935. When successful it gives admirable confirmatory evidence, but it is also misleading at times and is a measure to be used with some caution. The danger is air embolus. Hawthorne and Tidmarsh (20) are reporting such a case in a girl 12 years old with hypertensive cardiac disease, who died suddenly during an air injection to delineate the adrenals. Autopsy revealed the right heart filled with air emboli. Both adrenals were the seat of a pheochromocytoma with adrenal content of about 6 times the normal amount.

Recently Brodny and Chamberlin have devised an instrument calculated to minimize the danger from air embolism.

The fourth measure, operative exploration, may be the final court of appeal. The usual measures recognized are: (1) Exploration by abdominal section at which time both kidneys and both adrenals may be palpated; and (2) loin incision as for kidney on one or both sides.

It is not at all unlikely that unsuspected conditions of the adrenal or of the kidney may be found in the future to be the cause of that which at first appears to be an essential hypertension. The surgeon or neurosurgeon in his attack on essential hypertension by sympathectomy would be well advised to use the subdiaphragmatic loin incision of Adson, as this approach allows an excellent exposure of the adrenal and the kidney, as well as ease of exposure of the sympathetic chain.

Binger and Craig report the case of a young woman with essential hypertension. A splanchnicectomy on the left was done. Twelve days later there was a similar operation on the right. A marked drop of blood pressure occurred during the second operation, the patient's condition became poor and a transfusion was given; the left adrenal was palpated through the unopened perirenal capsule and seemed normal. After this second operation the blood pressure rose rapidly again, and it was thought that a hemorrhage had possibly occurred around the adrenal. The wound was re-opened, the adrenal was explored and found to be the seat of a new growth. On removal of this growth blood pressure dropped to the normal limits and remained so.

What is desired to be emphasized here is that in the surgical attack on essential hypertension by splanchnicectomy, the kidney and adrenal must be thoroughly exposed and examined, and that surgeon, neurosurgeon, and urologist should work as a team rather than attempt to achieve glory separately.

CLINICAL CONCLUSIONS

It is abundantly evident that hypertension in patients with pyelonephritis is relatively common. When unilateral and in the advanced stage, removal of the kidney has in many cases reduced the pressure permanently. In our clinic we have frequently had such results, and many other clinics report similar findings.

Certain pertinent questions naturally suggest themselves: What is the factor in this pathology that produces the hypertension? What can be done in the early cases of this infection to determine this factor? In such early cases nephrectomy is surely not justifiable; but in cases in which a destroyed kidney is removed, a more thorough examination of the specimen, especially the vascular system, should be made.

Many of these kidneys are found in very young patients and are of the small contracted type. In such cases, certainly in the ischemic group, a congenital element may in a measure be responsible.

Until these questions can be answered more satisfactorily, surgery in the early cases must still be regarded as in the experimental stage. In the polycystic kidneys any surgery for hypertension is to us questionable at present.

In obstructive lesions the procedure is much clearer and the relief of the obstruction is always indicated.

Finally, the pheochromocytoma group are difficult and delicate of diagnosis and treatment and require the utmost thoroughness and caution. But while diagnosis is often difficult, it has nevertheless recently made eminently satisfactory progress; and today because of this progress the profession is acquiring a more thorough knowledge of these conditions, and the results, surgical and otherwise, are proving most successful.

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COMPLICATIONS AND DANGERS OF LOWER URETERAL CALCULI

JOHN K. ORMOND, A.B., M.D., F.A.C.S., Detroit, Michigan

THE majority of patients with ureteral calculi will, after a more or less stormy and uncomfortable time, pass their little stones spontaneously. Often the most difficult part of the treatment is in persuading the patient that masterly inactivity is the proper program. The pain is often so violent that at first he is convinced his condition is dangerous, and it is necessary to disabuse his mind of this idea; then, when his fears are allayed, the pain of acute attacks, which he may continue to have, may be so trying that he is apt to feel he is being neglected. Complete confidence in his physician and complete understanding of the situation are essential for patient; equally important is a definite, unmistakable diagnosis on the part of the physician.

Even when the diagnosis has been made beyond possibility of mistake, when a clear idea of the probable course of events has been given to the patient, and when he has been shown that the pain, or at least one aspect of it, is desirable as an evidence that his tormentor is on the move, even then he may become impatient of the slowness of the course of events, and insistently attempt to push the surgeon into action against his better judgment. It is impossible to tell how long the ordeal will last; the stone may pass in a few hours or a few months.

In many of these patients the course of the stone can be traced by the progress of the pain even without the evidence of a roentgenogram. First pain in the back may come due to pelvic distention. The sharp pain may run then over the iliac crest down to the inguinal region, to the inner surface of the thigh, to the scrotum and testicle, or vulva. At first, even though the urine contain red blood cells, there may be no urinary symptoms; but later frequency occurs and marked urgency may mark the lodgment of the stone in the lowest part of the ureter and its expulsion into the bladder. As the stone passes through the urethra it may cause pain or a sudden stoppage of the urinary stream, followed by an explosive expulsion of the stone with relief of the urinary symptoms. This progression is familiar to all.

From the Division of Urology, Henry Ford Hospital.
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Unfortunately, not all patients pass through these stages. A few stones lodge in the upper ureter, but more in the lower or pelvic ureter, and it is with these latter that we are concerned.

When a patient has a stone lodged in the lower ureter, the surgeon's problem is to decide whether immediate operation is desirable, or whether it is possible to temporize and either do nothing, or attempt to facilitate the passage of the stone by cystoscopic manipulation. The data on which he must base his decision are: the size and position of this stone, the duration of the impaction, the condition of the affected kidney and of the one on the opposite side, the general condition of the patient, and, finally, a clear knowledge of the dangers and complications of lower ureteral calculi.

These complications and dangers can be divided conveniently into 3 groups: first, those due to the presence of the stone itself; second, those attendant on efforts at manipulative removal; and, third, those attendant on operation.

Group 1. Those associated with the stone itself are: (1) mistaken diagnosis, (2) hydro-ureter, (3) hydronephrosis, (4) pyelonephritis, acute and chronic, (5) uremia, (6) hemorrhage, (7) increase in size of the stone, (8) ureteral stricture, (9) peri-ureteritis, (10) peri-ureteral abscess, (11) ulceration through the ureteral wall, and (12) fistula.

Mistaken diagnoses are not nearly so common as they were a few years back. A right ureteral calculus may give pain in the right lower quadrant of the abdomen, often with a marked increase in the leucocyte count, and so has often been mistaken for appendicitis. The spread of education, the freer use of roentgenograms, and the use of the wax-tipped bougie have greatly reduced the frequency of this mistake. The mistake of making a diagnosis of stone when none is there is infrequent but does occur. The shadows of phleboliths in the roentgenogram rarely cause trouble, but occasionally calcified glands are confusing; and rarely a pigmented mole on the skin of the back may cast a shadow in the line of the ureter. The passage of a wax tipped catheter, or roentgenograms taken from various angles, with an opaque catheter in the ureter, will usually resolve all doubt.

Hydro-ureter, hydronephrosis, pyelonephritis, and uremia can all be considered together, since

they are all dependent on the obstruction of an impacted stone. These consequences of obstruction are those most to be guarded against of all the complications of stone, and are the ones which chiefly limit the possibility of temporizing in the treatment of stones. In nearly every case of impacted calculus there is some grade of dilatation of the ureter above and of the pelvis. The greater the obstruction and the longer it lasts, the greater this dilatation and consequent damage to the kidney. Fortunately, most stones, even the large ones, are channelled and there is also a condition of suspended function of the kidney which has been termed hibernation by Dourmashkin. This seems to be conservative, in that there is present temporary cessation of the increase in the pelvic pressure.

Even in instances in which the stone has been present for long periods, there is the possibility of at least partial recovery of renal function after its removal. This is not always the case, and in each instance the observer is faced with a nice question of judgment as to how long he may safely temporize. Of course with the very large stones temporizing is foolish, but it is with the border line cases we are most apt to do so.

Fortunately we now have at our disposal in intravenous urography, a convenient and painless method of watching the rate of both pelvic dilatation and of diminution of function.

With a normal kidney on the opposite side we are reasonably safe, for a kidney can stand considerable punishment. Experimental work seems to show that some degree of restoration of function is possible after the relief of complete obstruction which has lasted not more than 30 days. But when the opposite kidney shows much reduced function or absence of function, temporizing may be disastrous. In this connection I should like to cite a personal experience:

CASE 1. A young man about 25 years old entered the hospital on a Monday night complaining of having had left sided pain for 24 hours. The roentgenogram showed a shadow in the region of the lower left ureter. On cystoscopy obstruction was found at the left ureterovesical junction and no sign of the right side of the trigone nor of the right ureter. During 24 hours he passed only 200 cubic centimeters of urine, and the non-protein nitrogen of the blood rose slightly. On Wednesday another effort was made to manipulate the stone, and it was decided to operate the next day, provided the stone did not pass. During the night, however, his condition, which had previously seemed fairly good, changed suddenly. Edema of the lungs developed; an emergency nephrostomy was done, but he died within a couple of hours. Unfortunately, no autopsy could be obtained, but we believe that it was a case of congenital absence of the right kidney and ureter. The patient undoubtedly should have been operated upon the day he entered the hospital.

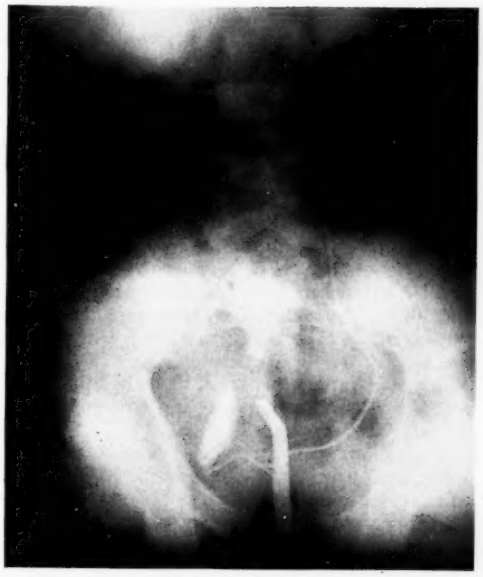

Fig. 1. An unusually large calculus in the lower ureter of a man. This could be palpated through the rectum. After removal there was some functional recovery of the kidney above.

We have had another patient with a solitary kidney due to a previous nephrectomy, who required emergency nephrostomy, and others with damaged or absent contralateral kidneys who developed mild uremia when a stone was lodged in the lower ureter.

Either at the onset of impaction or later there may be an acute infectious reaction with chills and high fever, subsiding into a condition of chronic pyelonephritis, with continued pyuria if the obstruction is not complete. This condition combined with distention can cause a rapid destruction of the functioning capacity of the kidney.

Recently we have been hearing a good deal about the effect of unilateral renal lesions in the production of arterial hypertension. Most of the cases reported have been associated with a disturbance of renal circulation, but there are a few cases on record in which relief of unilateral obstruction seems to have had a salutory effect on general arterial hypertension.

Though hemorrhage is a possibility and mild hematuria is common, I have never come across a case of serious hemorrhage, which must be very rare.

Increase in size of the stone must occur. Certainly some of the stones we see in the lower

ureter could not have reached that position in their present dimensions. Fortunately for the preservation of renal function, these large stones are often channelled; and after their removal, the affected kidney may be at least partly restored to health. We had an example of this in a male patient with an exceptionally large stone which was easily palpable by rectum. A few days after its removal the phthalein test showed returning function in the kidney above.

Stricture of the ureter is thought by some to cause stones, by others to cause their impaction, and by still others to be caused by irritation by the stone. Probably all 3 are true in individual instances. It is certainly true that many stones are associated with strictures, the dilatation of which is an important part of their therapy, either as an aid to their passage or to prevent post-operative recurrence.

Ulceration, peri-ureteritis, peri-ureteral abscess, and fistula may be considered together, since they are different stages of one process. All are familiar with the thickened ureter and the inflammatory reaction so often found around the stone at operation. Cases are on record of ulceration through the ureter causing abscesses which have burrowed and ruptured in the back, perineum, inguinal region, and thigh, sometimes with the discharge of the stone. Fistula occasionally results. Ockerblad recently reported a ureterovaginal fistula caused by the spontaneous ulceration of a stone. However, nowadays treatment is usually instituted before the condition has advanced beyond a rather mild peri-ureteritis.

Group 2. Complications and dangers attending efforts at non-operative removal are the following: (1) injury to ureteral mucosa, (2) stricture, (3) perforation of ureter, (4) peri-ureteritis, (5) peri-ureteral abscess, (6) temporizing too long, (7) hemorrhages, and (8) accidents such as loss of filiform, breakage of instrument, and catching, looping, or knotting of catheter.

Non-operative methods of removal or manipulation consist of various procedures: dilating the ureter below the stone, passing catheters or bougies past the stone, injecting various substances into the ureter above the stone, engaging the stone in various devices such as corkscrew, spiral wires, or multiple cords, and ureteral meatotomy by means of the cystoscopic scissors or the cutting current. Any of these may cause slight injury to the mucosa, usually of no consequence but occasionally so. A stricture may result. Perforation of the ureter by bougie or by a catheter containing a stilette in the absence of infection has occurred without harm. On the other hand the ureter may be perforated by the metal instruments and peri-ureteritis and abscess result. We have seen 1 such case.

Another possibility is breakage or separation of a portion of the instrument within the ureter, or the catheter or other device may knot itself above the stone and be difficult to withdraw. I have seen one instance of the latter in which, fortunately, at the end of 24 hours it was withdrawn readily. I have also seen the filiform of the Walther dilator unscrewed and left in the ureter, from which it was expelled spontaneously at the end of 2 days. This, however, was not a case of stone.

It seems best not to use these devices for the purpose of forcibly extracting the stone, but merely to engage it, thus dislodging the stone and stimulating or facilitating its expulsion. There is less possibility of damaging the ureter by so doing, than by attempting forcible extraction; though I have seen stones at the ureteral meatus dragged out without harm.

Another danger of manipulation is the possibility of temporizing too long. Each manipulation arouses expectation of expulsion, and, as in the case cited earlier, the period of watchful waiting may be prolonged beyond the safe point. Under ordinary circumstances the size of the stone and the availability of the patient are the determining factors. Most stones of less than 1 centimeter in the narrowest dimension will pass, and fairly prolonged temporizing may be permissible, provided obstruction is not marked. However, with stones of this size or even smaller, if the patient lives at such a distance that frequent observations are not possible, the period of temporizing may be cut very short and resort had to operation earlier.

With larger stones one is occasionally astonished at the effect of manipulation. At the urgent solicitation of one patient we unwillingly manipulated a large stone in the lower ureter and proceeded, nevertheless, with our preparations for its operative removal the next day. However, the roentgenogram on the way to the operating room the next day showed that the stone had passed into the bladder from which it had to be removed by the lithotrite.

Meatotomy performed either with cystoscopic scissors or by means of the cutting current may facilitate the passage of a stone, but occasionally results in troublesome, though not dangerous, hemorrhage. In one such case removal of blood clots from the bladder by suction proved necessary.

Group 3. Complications and dangers of operative removal are: (1) ordinary operative complications, (2) hemorrhage, (3) stricture,

(4) kink, (5) infection, (6) movability, (7) overlooking stone or part of it, and (8) fistula.

The dangers of pneumonia, phlebitis, and other complications of all operative procedures must be faced, but we are concerned here with only those attending this particular operation.

There is almost certain to be urinary drainage for a longer or shorter period and very occasionally a true fistula results depending often on stricture formation below, either pre-existing or resulting from operative damage to the ureter. This is rare. Occasionally the scar resulting from the drainage tract may draw the ureter out of the normal path causing a kink. On one occasion, we were unable to pass an ordinary catheter up past the kink. However, on making a smooth wax bulb on the end of a bougie we were able to pass it, thus straightening the ureter and relieving the partial obstruction which had resulted.

In any drained wound there is of course a certain amount of infection; and whenever urine drains for a time, particularly if the urine is itself infected, the infection occasionally may amount to an abscess.

Movability of a stone may cause embarrassment, for if the ureter above is much dilated, the stone, if round and reasonably smooth, may move back into the ureter and not be found at operation. We invariably have a roentgenogram taken on the way to the operating room to make certain of the position of a stone; but in spite of this precaution, we had the embarrassment on one occasion to be forced to operate a second time to remove a stone which had returned to the pelvis. On another occasion a large stone had moved upward, but in this case we found a much dilated ureter above a dense stricture at the ureterovesical juncture and felt it best to cut the ureter above and re-implant it into the bladder, in consequence of which, the stone was expelled into the bladder a couple of days later. It is possible that portions of stones may be left behind, though if catheters or uterine probes be passed both ways from the operative incision this is unlikely to occur.

Troublesome bleeding may occur from the veins about the bladder, but dangerous hemorrhage is rare. However, erosion of the iliac artery has occurred. Moschkowitz some 30 years ago, reported bilateral erosion of external iliacs following bilateral ureterolithotomy due to rubber drains. More recently de la Marnierre reported an instance of hemorrhage from one iliac 15 days after removal of a drain, which had been allowed to remain in place only 2 days. This past year we have had a very unpleasant experience which is worth detailing.

CASE 2. After the removal of a stone from the lower left ureter of a man aged 55 years, the wound healed slowly, repeatedly broke open, and ureteral obstruction recurred which required repeated dilatation. At the end of 9 weeks the wound was still draining. One evening as the resident lifted off the dressings, there was a spurt of blood as if from a small hose. He immediately made pressure on the iliac through the abdominal wall and sent for assistance. Abdominal pressure was maintained until an operating table could be brought to the room. There the wound was tightly packed, the abdomen opened, and the external iliac artery ligated. Twenty days later it was necessary to amputate the left leg between the ankle and the knee due partly to the ligation of the external iliac and partly to a pre-existing disease of the veins of this leg.

CONCLUSIONS

If all patients with lower ureteral calculi were neglected, the great majority would recover unscathed. But a few would suffer more or less serious harm and this harm we wish to prevent.

Each case of ureteral calculus, therefore, presents the following questions: Is immediate operation desirable? If not, should manipulation be tried? If so, what method should be used? How long is it safe to temporize?

Each must be guided by his own experience, judgment, and skill. I have come to the conclusion that only the less drastic forms of manipulation are indicated. Patients with stones, the expulsion of which cannot be stimulated by the gentler measures, should be operated upon when and if the stones have been given a reasonable opportunity to be expelled. The time constituting a reasonable opportunity will be measured by the amount of disability caused by the pain, and by careful evaluation of the damage produced. I have seen a stone lodged in the lower ureter expelled after 6 months of careful observation. This stone caused in that time only 4 days of disability and no appreciable damage to the kidney. On the other hand, I am afraid that some patients treated by multiple manipulations have been subjected to more danger, have suffered more pain, and lost more time, than if they had been operated upon in the first place.

In all cases, whether operative or not, attempts to prevent recurrence should be made. Ureteral dilatation; pelvic irrigation; treatment of infection; attention to diet, fluid intake, and to changing urinary reaction will usually prevent recurrences.

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THE DEVELOPMENT OF PROSTATIC HYPERPLASIAS

CLYDE L. DEMING, M.D., Sc.D., F.A.C.S., New Haven, Connecticut

THE current views concerning the development of so called prostatic hypertrophy do not emanate from the urological field alone but from most of the fields of medicine. In spite of the many hypotheses, very little actual progress has been made in the solution of this problem since Sir Everard Home so well described the enlarged prostate 140 years ago. The prostatic gland has a tendency to enlarge at the age of 50 years. Autopsies in men past 50 years corroborate this fact. Sixty-five per cent of men at 65 have some prostatic enlargement. Medicine and public health have done much to lengthen man's life span; and, since prostatic enlargement is a disease of elderly men, we find that the lesion must of necessity become more common. Longevity, then, is the fertile field for the development of prostatic overgrowth and causes our problem to assume greater proportions than ever before.

What do we actually know about the development of "prostatic hypertrophy"? Very little. We do not have any actual knowledge of its causes. Experimental work in animals has produced a physiological hypertrophy but not a pathological enlargement comparable to the benign prostatic enlargement seen in man. We are inclined, however, to believe—but we do not have any positive data—that the lesion in man is due to an imbalance of male and female hormones in favor of the female hormone. Consequently, scientists have proposed the treatment of the lesion by testicular hormone. Results of such treatment in this country and abroad produce grave doubts as to the value of this therapy beyond producing a temporary hypertonicity of muscles. In fact, a recent report by Heckel would definitely indicate detrimental effects from the use of this therapy by causing aspermatogenesis. To some individuals, even prostatics, this latter effect might be welcome. We have no means at present to prevent the development of "prostatic hypertrophy" except castration early in life and no control of its growth after it has once begun.

We know from our patients that the first symptom of prostatic overgrowth is usually a little frequency in urination. As the enlargement becomes more evident, increased frequency and, finally, complete obstruction to urination occur. In other individuals, complete obstruction to urination may occur dramatically and suddenly after coitus, ingestion of alcohol, or exposure to cold. The clinician can deduct fairly accurately that in the first group of patients, who have a gradual onset of symptoms, the growth of the prostate involves the middle lobe; while in the second group of patients, who have a sudden bladder neck obstruction, the lateral lobes are the obstructing factor. The cystoscopist confirms these conclusions. The surgeon finds an excessive growth of tissue which is encapsulated, lies close to the mucous membrane of the prostatic urethra, and compresses the normal lateral lobes into a thin sheet of tissue. The mass of tissue removed at operation may represent one or two lateral lobes, a median lobe, and an occasional group of spheroids, or single scattered spheroids, which are themselves encapsulated. The pathologist describes the surgical specimens as composed of tissue predominantly glandular but with varying amounts of muscle and fibrous tissue.

Since the clinician and pathologist have come to common terms and agree that the histology is not characteristic of adenoma, myoma, or fibroma, we shall call the lesion a benign enlargement. We can also employ one more common fact: benign prostatic enlargement is composed of three tissues, glandular, muscular, and fibrous. Since the normal prostatic gland is composed of these three tissues, it is highly probable that the benign lesion develops from one or more of these three primary component tissues.

It is the purpose of this paper to show where and how "prostatic hypertrophy" develops, to demonstrate that it is a neoplastic, hyperplastic, rather than a hypertrophic lesion, and to produce evidence in support of the hypothesis that it is derived from an embryological anlage. Since animal experimentation has failed thus far to produce a histological lesion comparable to that seen in man, it seems at present that the only approach to this problem is the study of the lesion in its early phases.

During the past 5 years, the author has been making serial sections of prostates removed at autopsy. Prostates of normal size with minute

From the departments of Surgery and Pathology, School of Medicine, Yale University, and the New Haven Hospital.

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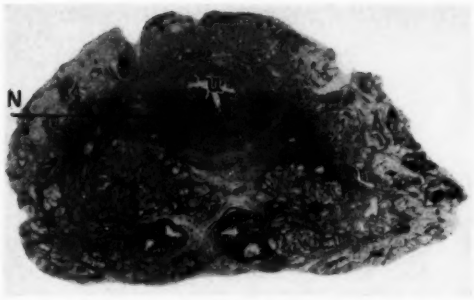

Fig. 1. Histological section of prostate of man 58 years. Showing minute fibromuscular nodule, *N*, in muscular wall of urethra, *U*. No glandular hyperplasia. × 1.6.

gross or microscopic lesions have been prepared for microscopic serial section study. In the normal prostate, the relative amounts of glandular tissue, muscular tissue, and fibrous tissue vary as to age. In the infant and the aged with an atrophic prostate, the proportion of glandular tissue is relatively small. After adolescence and during early adult life, glandular tissue is preponderant. After the age of 40 years, the glands in the lateral lobes become somewhat dilated and cystic. During the fifth, sixth, and seventh decades, the glands become less active, and their epithelium is definitely diminished in height. The relative amounts of glandular tissue vary also in different locations of the prostatic gland, including the prostatic urethra. At the bladder neck the muscular wall of the urethra is well developed and thick and is relatively free from glands and ducts. On the contrary, near the verumontanum the muscular wall of the urethra is pierced by large numbers of ducts and some glands.

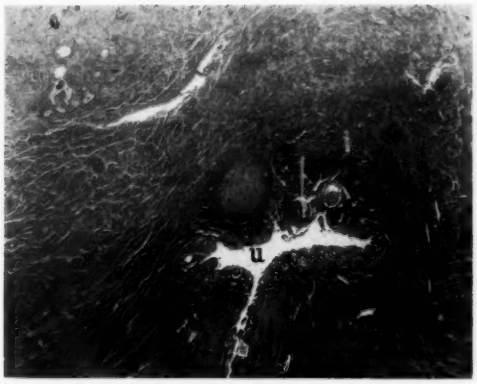

Fig. 2. Photomicrograph of histological section of prostate of man 84 years. Showing single fibromuscular nodule beneath mucous membrane of urethra, *U*. No glandular hyperplasia.

Fig. 3. Histological section of prostate of man 64 years. Note numerous small, whitish areas in muscular wall below the floor of the urethra. These areas represent developing fibromuscular masses. The left muscular wall of the urethra shows two well developed, glandular nodules below which are many focal points of fibromuscular and glandular activity. × 1.9.

It was assumed for a long time that since the majority of the surgical specimens contained a preponderance of glandular tissue histologically, the benign prostatic enlargement developed from glandular tissue. Albarran thought that since these enlargements were found just under the mucosa of the prostatic urethra, they developed from subepithelial or subtrigonal glands; Zuckerkandl (22) believed that the prespermatic lobe

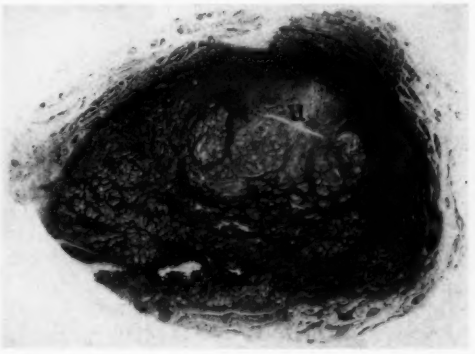

Fig. 4. Histological section of prostate of man 60 years. Showing fibromuscular and glandular nodules in the muscular wall of the urethra below the floor. *U* shows the urethra. ×1.6.

Fig. 5. Histological section of prostate of man 68 years. Showing asymmetrical enlargement of lateral lobes in the muscular wall of the urethra. The right lobe is predominantly glandular but contains a few residual fibromuscular nodules. The left lobe contains numerous small fibromuscular nodules with beginning glandular hyperplasia. *U*, marks the urethra. ×1.5.

was responsible. Marion believed that these glandular masses could develop from any glandular element of the prostatic gland.

The author wishes to produce evidence that the glandular theory of development is probably false. Velpeau, in 1841, Thompson, in 1873, Kausch, in 1929, and Reischauer, in 1934, recognized fibromuscular and glandular masses. There are over 30 cases of prostatism reported in the

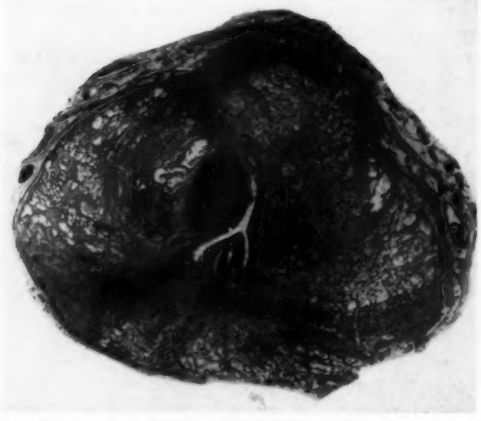

Fig. 6. Histological section of prostate of man 68 years. Showing fibromuscular nodule in lateral wall of urethra. The nodule is being invaded laterally by glands. ×1.9.

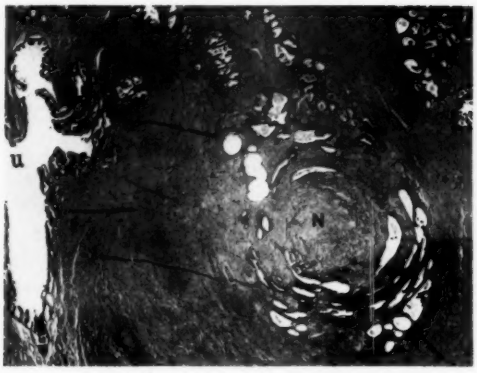

Fig. 7. Histological section of prostatic urethra of man 70 years. Showing small fibromuscular nodule being invaded centripetally. *U*, marks the urethra, *N*, the nodule. ×13.

literature in which the enlargement was composed of nonstriated muscle and fibrous tissue. These masses involved 1, 2, or all 3 lobes and have been described as "leiomyomas." Patch and Rhea found that 25.4 per cent of 181 consecutive surgical specimens of so called prostatic hypertrophy showed leiomyomatous nodules varying in size from 0.5 to 3 millimeters in diameter.

Our study of autopsy specimens of prostates from men over 45 years of age has shown, in addition to glandular masses, rounded, aglandular, muscular masses close to the urethra. In the early phase, glandular masses never exist without the presence of muscular hyperplasia or fibromuscular masses. The aglandular or fibromuscular mass frequently occurs independently and without the presence of glandular hyperplasia. They, however, usually occur together. The more

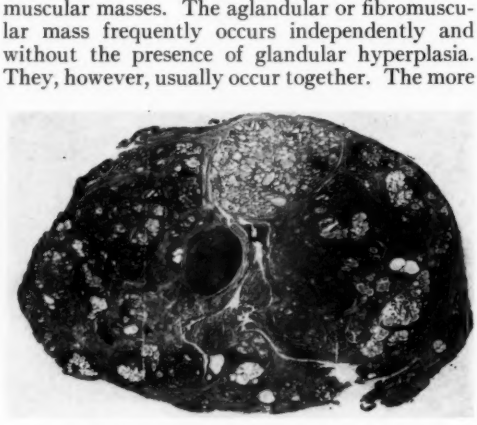

Fig. 8. Section of specimen weighing 168 grams, of prostate of man 68. 1 fibromuscular nodule adjacent to urethra. Most of the tumor is glandular. *U*, the urethra. ×1.24.

we look for aglandular masses, the more frequently they are found. It is apparent that aglandular and glandular masses are formed early in the development of benign prostatic enlargement. What part, if any, do the aglandular masses play in the production of a full grown prostatic enlargement? What is their relation to the glandular masses? From what tissue or tissues do the aglandular and glandular masses arise?[1]

From the study of thousands of serial sections of early lesions of the prostate and urethra, the author finds fibromuscular hyperplasia and aglandular nodules in the muscular wall of the posterior urethra. The aglandular or fibromuscular masses may be single but are more often multiple and bilateral, located anywhere within the musculature of the urethral wall between the external and internal sphincters. As many as 16 aglandular masses have been found at one level. They are more common near the verumontanum. They vary in length from 500 to 20,000 microns. As they develop in size, they tend to become cigar-shaped or oblong and later become encapsulated. As the result of localized outgrowths or of the union of two or more developing centers, they may assume a nodular appearance (Figs. 1 and 2). The fibromuscular mass begins as a hyperplasia of fibromuscular tissue between the muscle fibers of the urethral wall but not in the true prostatic glandular substance *per se*. Again, it appears as hyperplastic fibrils around a tiny blood vessel but never around the prostatic ducts. As the fibromuscular mass increases in size, new blood vessels appear within it. Later its stroma becomes more compact, and the tissue at the periphery of the mass takes on a fibrous tissue capsule which is probably the result of compression (Fig. 3).

The minute glandular nodules vary in size and are surrounded by circular fibers of fibromuscular tissue. The acini within a nodule may show active budding epithelial projections and dilated cystic areas. Cystic dilatations appear early, but corpora amylacea are not seen in the early lesions. Like the fibromuscular nodules, the glandular nodules are first seen in the muscular wall of the urethra and not in the true lateral and posterior lobes of the prostate. When these nodules increase in size, they deflect the urethra greatly, compress the true lateral and posterior lobes, and appear as lateral lobes on either side of the urethra. They do not develop from the suburethral glands of Albarran, as was formerly

[1] "Fibromuscular mass" and "aglandular nodule" will be referred to as lesions which are histologically similar, with the exception that the latter represents a later stage of development and is usually encapsulated.

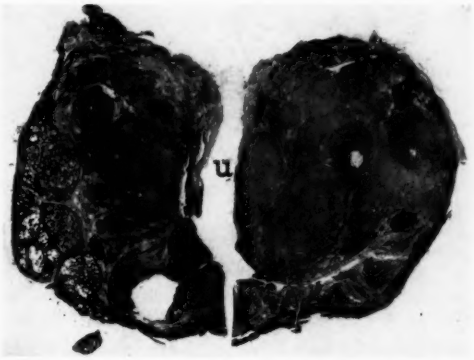

Fig. 9. Histological section of surgical specimen of prostate of man 80 years. Showing mostly fibromuscular tissue with a few glands in the left lobe. *U*, marks the urethra. ×1.24.

thought, because these nodules are formed well within the muscular coat of the urethra (Figs. 4 and 5).

The study of many nodules cut serially has led the author to conclude that the glandular nodule is a result of the invasion of an aglandular mass or nodule by epithelial buds from an adjacent duct. These epithelial buds may enter the solid fibromuscular tissue mass laterally or centripetally and form glands. One can readily demonstrate this epithelial response on the inside of a duct adjacent to an aglandular nodule while directly across its lumen the epithelium lies dormant. The growth of the fibromuscular tissue is apparently much slower than the growth of the glandular tissue. For this reason, the primary fibromuscular mass may be partially or entirely invaded by the more rapidly growing epithelial tissue, with the result that the full grown nodule appears glandular. As the peripheral muscle tissue becomes compressed, it forms the "surgical capsule" of the glandular mass which is seen in the surgical specimen (Figs. 6 and 7.)

Glandular nodules have not been found in the lateral and posterior lobes in the early stages of the development of so called prostatic hypertrophy. Aglandular nodules have been seen in the roof of the urethra and below the crista urethralis, from which anterior and middle lobes respectively could theoretically develop. Thus we have found the anatomical location for the development of the lobes seen clinically. While enlargement of any one or all of these lobes can be diagnosed clinically, cystoscopic and digital examinations do not tell us whether the enlarged lobes are glandular, aglandular, or a mixture of these tissues

Fig. 10. Schematic drawing of dissemination of muscle fibers of muellerian duct in wall of posterior urethra.

Thus far we have ascertained that the physical development of benign enlargement of the prostate passes through two phases: first, the formation of the fibromuscular nodule; and, second, the invasion of the primary fibromuscular nodule by epithelial tissue and the formation of glands which simulate normal prostatic glands. What are the forces behind these developments?

The evidence so far produced would indicate that the fibromuscular masses develop before there is any evidence of glandular hyperplasia, that they appear in the muscular wall of the urethra, and that they are most frequently located near the verumontanum and in the floor of the urethra. They are not found in the capsule, in the lateral lobes, or in the posterior lobe of the prostatic gland. The aglandular masses become infiltrated most rapidly near the verumontanum, where a larger number of ducts pierce the urethra. The aglandular nodules remain aglandular where there are not any ducts, or but few ducts, that is, close to the urethral mucous membrane and near the vesical neck. The study of surgical specimens cut serially corroborates this finding (Figs. 8 and 9). Occasionally, one finds a prostatic specimen which contains small glandular masses without much hyperplasia of the fibromuscular stroma. The occurrence of such tumors may be explained on the basis that the early hyperplasia of the fibromuscular tissue causes such a rapid growth of the epithelial tissue that the glandular masses are formed before aglandular masses have time to develop. The early glandular masses appear in the same locations as the aglandular masses and not elsewhere. They are formed from hyperplastic ductal epithelium which has invaded the solid fibromuscular mass. It would seem that the glandular development is a secondary phase of hyperplastic prostatic growth and not a primary one; and, further, that the hyperplastic fibromuscular tissue has inherent qualities which stimulate epithelial growth and cause the epithelium to invade the less rapidly growing fibromuscular tissue.

This method of glandular tissue formation from ducts is similar to that seen in the normal embryological budding from the posterior urethra, whose mucous membrane forms the anlage of the prostatic gland. This epithelial response may be a reawakening of the activity possessed by the ducts during the embryological development of the gland.

The primary fibromuscular nodule found in the development of so called prostatic hypertrophy closely resembles the uterine myoma in its appearance, muscle arrangement, and staining qualities. As we have stated before, the fibromuscular nodules occur in greatest numbers near the verumontanum. The utriculus masculinus is a homologue of the uterus and is derived embryologically from the Muellerian duct system. In their exhaustive study of the embryology of the prostate, Lowsley and Walker both state that the muscle fibers of the Muellerian duct system pierce the posterior urethra near the verumontanum and entwine themselves with the regular muscle fibers of the urethra (Fig. 10). Since the uterine myoma is derived from a muscle cell, may not the primary prostatic tumor also have its origin in one of the muscle cells of the lower Muellerian duct system? It seems fair to assume that the uterine myoma and the primary lesion of prostatic overgrowth have a common embryological anlage.

This hypothesis can be supported by two observations, one clinical and the other experimental. Clinically, the surgeon not infrequently experiences a difficult suprapubic enucleation because of adhesions in the posterior urethra. The pathologist, on examining these specimens, notes the incorporation of the verumontanum with the specimen. It is well known to the cystoscopist that these tumors grow some distance distally to the verumontanum. The experimental factor in this hypothesis is found in the response of the tissues of the posterior urethra to hormonal therapy. Van Wagenen, Jenkins, and others have noted a great thickening of the epithelium of the utricle in rats and monkeys after injection of the female hormone. The utricle contains the anlage, an anatomical structure such as is present in the uterus, where muscular fibers and glandular elements are extraordinarily sensitive to hormonal agents of the estrogenic series. It is reasonable, then, to hypothecate that the primary nodule in the development of prostatic "hypertrophy" has for an anatomical basis the anlage of

the Muellerian duct system. The activating principle responsible for its growth may be some member of the estrogenic series.

For further evidence of the possible influence of estrogenic hormones on fibromuscular and glandular growth, one must make reference to the fibro-adenomas of the breast. Here the periductal and peri-acinic fibromuscular element shows much hyperplastic activity. There is also a multiplication of the ducts and glands. Geschickter's work suggests that this lesion is one whose development may be due to an estrogenic factor. While the lesions of both the breast and the prostate are histologically benign, they are subject to malignant changes.

One should not be permitted to pass on in the face of these findings without reference to some of the older theories of the development of "prostatic hypertrophy." Guyon, Loeschke, Adrion, and Kausch, who are the main proponents of the arteriosclerotic theory, must admit that arteriosclerosis does not always occur in individuals who are suffering from benign enlargement of the prostate. It is equally true that many patients who have arteriosclerosis do not have any evidence of prostatic enlargement. Kausch's fanciful theory of arteriosclerotic involvement of the arteries of the outer glands of the prostatic urethra seems definitely disproved by this serial section study. Ciechanowski, Rothschild, Hirsch, and Greene and Brooks have favored an inflammatory theory. The infection, which is a frequent finding in cases of prostatic enlargement, produces a local fibrous tissue development which obstructs the ducts and glands and causes them to become dilated and enlarged. It is true that the serial study of many prostates shows round cell infiltration and some evidence of inflammation. It is likewise true that many sections of surgical specimens fail to show any changes due to inflammation. Cabot and Smith clearly demonstrate in the follow-up of men with histories of infection through middle life to the age of prostatism that there is less likelihood of the development of so called prostatic hypertrophy in this group as compared with a similar group of individuals who have never had prostatic infections. The functional and constitutional theories of the development of prostatic enlargement are interwoven with hormonal arguments, and we have not sufficient positive data to discuss them intelligently at this time. Further studies in embryology might give more positive evidence.

The neoplastic theory of enlargement of the prostate, although rejected by Ewing, has certain phases in its favor. The primary tumor resembles the uterine myoma, which is neoplastic and probably has the same or similar structural origins. That a certain number, 12 to 20 per cent, of the surgical specimens removed for benign enlargement show malignant characters is a well recognized fact. The tissues which compose benign tumors of the prostate, both fibromuscular and glandular, are certainly not just enlargements of the existing elements but duplications by many times. The primary muscular elements invite epithelial hyperplasia and development of glands similar in appearance to the glands seen in the normal prostate. The term "hypertrophy of the prostate" should be applied only to physiological increase in size of the prostatic gland without multiplication of its components. It is evident from this study that benign enlargement of the prostate in elderly men is not hypertrophied tissue but hyperplastic tissue which has a tendency to develop from many focal points, to grow without limit, and ultimately to cause the death of the individual.

CONCLUSIONS

1. The early phases of benign prostatic overgrowth are found in the muscular walls of the posterior urethra in autopsy specimens.
2. The benign prostatic overgrowth usually passes through two phases of development.
3. The first phase is the development of a fibromuscular mass from the intramuscular stroma of the posterior urethra.
4. The second phase is the invasion of the fibromuscular nodule by the epithelium of a prostatic duct.
5. This epithelial proliferation develops prostatic glands and ducts of normal appearance.
6. The epithelial element overgrows the fibromuscular element so as to make the full grown lesion appear glandular.
7. The glands in the posterior urethra and prostate are not primarily involved.
8. The primary fibromuscular nodule resembles the fibromyoma of the uterus and may be derived from a remnant of the Muellerian duct musculature.
9. Benign overgrowth of the prostate is hyperplastic tissue, not hypertrophied tissue.

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PERIRENAL ABSCESS

H. G. HAMER, M.D., F.A.C.S., Indianapolis, Indiana

SUPPURATION in the fatty tissue surrounding the kidney is uncommon, especially when one considers the frequency of surgical lesions within the kidney. Because of the difficulty of diagnosis in the early stages and the fact that its pathology is still undetermined, perirenal abscess is of interest not only to the urologist but to all those interested in medicine.

Confusion concerning the nomenclature arises from the fact that perinephritic abscess has been referred to as primary, when it originates in the perinephritic tissue, or secondary, when it originates in the kidney or some other focus. Since there is much evidence to demonstrate that perirenal infection is secondary to infection in the kidney or in the surrounding organs or tissues, it would seem reasonable to regard all occurrences of perirenal abscess as secondary.

In classifying perirenal abscesses it seems logical to call all abscesses within the fascial envelope of the kidney, or Gerota's fascia which develop from a perinephritis, true perinephritic abscesses, whether they originate from an existing renal disease, such as pyonephrosis, nephrolithiasis or tuberculosis, or cortical metastatic renal infection; and all others which arise from infection of adjacent organs and tissues should be classed as false perinephritic abscesses, whether subdiaphragmatic, subphrenic, or psoas.

Metastatic infection of the perirenal fat without involvement of the kidney is conceivable as no portion of the body is exempt from such occurrence, and a few cases have been reported in which no evidence of renal infection was found. When abscess occurs in connection with pyonephrosis, lithiasis, or tuberculosis, the diagnosis is not difficult, as symptoms which point to infection in the urinary tract are usually not wanting. But in metastatic infection of the renal cortex diagnosis may be difficult and delayed, and often a perinephritic abscess is the only indication of renal infection.

It is conceded that septic emboli may find lodgment in the perirenal tissues just as in any other organ, yet the point has not been sufficiently supported by evidences found at operation or autopsy to be convincing beyond doubt. The long period of time from the localization of the infection to the time when diagnosis is made gives opportunity for healing of small cortical abscesses which might not be found even at autopsy, and less likely at operation.

Hunt's finding of a renal source in over 50 per cent of his cases, in which an examination of the kidney was made during operation for perinephritic abscess, is significant. In operating for relief of perinephritic abscess, examination is frequently and properly omitted as being an imprudent procedure, which would only add to the dangers already present.

Cabot has called attention to the frequency and importance of coccic infection of the kidney, particularly in the milder cases. He believes that they are more common than is generally supposed, and are much more common than the septic infarct described by Brewer. Spontaneous healing in these mild cases of coccic renal infection may occur and probably often does occur. The reaction of the kidney under the circumstances probably depends upon several factors, i.e., number and virulence of bacteria, resistance of the tissues to the staphylococcic toxins, etc. In certain of these infections perinephritic abscess occurs. Trauma may play a part but probably it is not so much of a factor as it was thought to be by earlier writers. The frequency of unilateral as against bilateral occurrence may be due to some local condition; in one kidney a condition may exist which predisposes to infection, or, if the infection is bilateral, a local condition in 1 kidney may prevent its recovery.

The grouping of perirenal abscesses given by Fowler and Dorman is eminently satisfactory: (1) Those having origin in destructive lesions of the kidney, such as pyonephrosis, nephrolithiasis, tuberculosis, etc. (2) Metastatic abscesses in which there is a history of a remote focus of infection in boil, carbuncle, paronychia, respiratory infection, etc. Cases which arise from foci of lymphatic extension, as from pelvic disease, cannot be excluded but probably form an unimportant group. (3) Those rare cases caused by direct extension from suppuration in neighboring organs such as retrocecal abscess, subphrenic abscess, and empyema.

In the group secondary to existing renal disease

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urological study usually furnishes helpful diagnostic evidence. The metastatic group is of most concern because of the severity of symptoms and the difficulty of diagnosis. In the majority of cases the staphylococcus is the infecting organism.

The clinical picture of suppurative perinephritis is similar to that of acute renal infection. Since the perinephritic abscess originates as a rule in an acute cortical abscess of the kidney, it is impossible to distinguish between the two in their earliest stages. But when the acute stage has passed, chronic perinephritic abscess differs markedly in its characteristics from chronic pyelonephritis. Often no pus appears in the urine, the function of the affected kidney is not much impaired, and the infecting organism may or may not be found by culture of the urine from the diseased kidney. The characteristic symptoms are pain, tenderness, fever of the septic type, and palpable mass in the region of the kidney. Chill and fever usher in the attack. The pain is generally confined to the loin, dull aching in character, and increased by movements of the body or flexion of the leg of the affected side. There may be nausea and vomiting with possible loss of weight. The patient often becomes profoundly septic. The tumor in the loin may be fluctuant and non-movable on respiration.

If drainage is delayed, the patient may die of sepsis or the abscess may become chronic; and there is the possibility that spontaneous recovery may occur by rupture of the abscess through the skin or into one of the neighboring viscera or even by resorption of the pus.

Diagnosis is made usually on physical findings; the urological study is often negative, especially in the metastatic group of cases. The existence of kidney disease, such as stone, tuberculosis, or pyonephrosis, would direct suspicion toward a suppurative perinephritis in the presence of pain, costovertebral tenderness, and tumor. Urinalysis may or may not give positive evidence; it depends upon the time it is taken and the care exercised.

The following points are of value in diagnosis: (1) History of remote staphylococcic infection such as boil, carbuncle, paronychia, infected wound, and respiratory infection; (2) the clinical course of an obscure sepsis, high leucocytosis, picket fence type of fever; (3) the roentgenogram may show scoliosis with concavity of the spinal curvature toward the affected side, obscuration of the renal area and of the margin of the psoas muscle; (4) costovertebral pain and tenderness; (5) fullness or indefinite mass on palpation in the flank, which is immovable on respiration, and rigidity of muscles.

Perirenal abscess should be diagnosed and drained as early as possible. In early cases suppuration within or without the fatty capsule of the kidney will show whether its origin is renal or not. But if the abscess is of long standing the primary effort should be simply to drain it and leave the treatment of other lesions for subsequent consideration. The necessity for nephrectomy is determined by the condition of the kidney; usually it is wise to postpone nephrectomy until drainage has relieved the sepsis.

SUMMARY OF CASES

In the author's series of 34 cases of abscess in the perirenal space there were 20 males and 14 females. Their ages ranged from 10 to 65 years; the average was 36 years. Arranged according to decades 1 appeared in the first, 5 in the second, 9 in the third, 6 in the fourth, 5 in the fifth, 5 in the sixth, and 3 in the seventh decade.

The duration of symptoms before diagnosis varied from a few days to a year; the average duration was 6 weeks.

A history of possible predisposing disease was obtained in 25, including furunculosis, carbuncle, infected wound, appendicitis, tonsillitis, mastoiditis, influenza, leg ulcer, infected hemorrhoids, cholelithiasis, renal calculus, renal tuberculosis, and urinary infection. Seventeen involved the right side, 12 the left, and 3 were bilateral. In 2 the side involved was not recorded.

A history of previous urinary infection was obtained in 15, which varied from mild to severe, and included cystitis, pyelitis, lithiasis, pyonephrosis, and tuberculosis.

Fever was of the septic type in all; likewise pain, variable tumor mass, and costovertebral tenderness were present in all patients. Leucocytosis varied from 7,600 to 31,000 and averaged 15,500. The hemoglobin was consistently low; the average was 65 per cent. The urine showed pus and albumin in variable amounts in 26 cases. Roentgenographic examination in 20 of the cases showed obscuration of the border of the psoas muscle in 6.

Of the 34 patients all were operated upon but 3, 2 of whom died of sepsis. Autopsy in both instances showed the origin of the perirenal abscess to be carbuncle of the kidney. One patient not operated upon recovered spontaneously. Of those operated upon 22 recovered promptly after drainage, and 4 were nephrectomized later for calculus or tuberculous pyonephrosis. Seven died in the hospital either of sepsis or cardiac disease. Among these was a 65 year old male who died of sepsis. The autopsy showed multiple cortical abscesses

of the kidney on the affected side. In the case of a 55 year old female a filling defect showed in the pyelogram of the affected kidney, in which a cortical abscess was found to be the cause of a perinephritic abscess. In a 55 year old male a renal calculus perforated the renal pelvis and was found in the perirenal abscess. Eighteen cases had definite evidences of renal disease in the form of pyonephrosis, lithiasis, tuberculosis, septic infarct, massive cortical abscess or carbuncle, and multiple parenchymal abscess. In 1 case the abscess followed injury to the loin. In 3 cases the abscess was an extension of a postcecal abscess. A 10 year old boy had an abscess beneath the sheath of the erector spinæ muscle, probably a metastatic infection from a recent mastoiditis.

The infecting organism was the staphylococcus in 18 cases, staphylococcus and streptococcus in 8 cases, and staphylococcus, streptococcus, and colon bacillus in 2 cases. In the remaining cases the type of organism was not recorded.

CONCLUSIONS

1. Perinephritic abscess of extrarenal origin in most cases is the result of blood-borne infection to the renal cortex followed by cortical abscess with extension to the perirenal tissues. The source of the infection is some remote focus such as carbuncle, boil, infected wound, or respiratory infection. Calculous disease and tuberculosis are the most common causes of perinephritic abscess of renal origin.

2. The infecting organism is usually one of the pyogenic coccus group.

3. The chief symptoms are pain and tumor in the loin, with costovertebral tenderness, fever of the septic type, and high leucocytosis.

4. Diagnosis in the early stages is most difficult. Urological study is of value in the cases of primary renal disease, but in most of the metastatic cases positive urological evidence is lacking.

5. Roentgenograms may show a clouded renal area, obscuration of the border of the psoas muscle, and scoliosis.

6. Thorough drainage is emphasized. In the metastatic type simple drainage is usually followed by prompt recovery. In the type secondary to existing renal disease nephrotomy or nephrectomy may be required. Nephrectomy is usually postponed until drainage has relieved the patient of his sepsis.

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END-RESULTS OF CARCINOMA OF THE BLADDER TREATED BY RADIUM

BENJAMIN S. BARRINGER, M.D., F.A.C.S., New York, New York

ACCORDING to the 1937 report of the Division of Vital Statistics of the Bureau of the Census there were 144,774 deaths from cancer, of which 4,651 or 3.2 per cent were due to cancer of the bladder. This percentage is about one-half of that of cancer of the prostate, or 7.59 per cent, and one-quarter of that of cancer of the breast which is 13.93 per cent.

The results from 4 cities have been tabulated and the percentages of all cases of cancer under treatment with primary cancer of the bladder are as follows: Atlanta, 1.9 per cent; Detroit, 2.6 per cent; Pittsburgh, 3.5 per cent; and Chicago, 4.1 per cent. These figures are for the calendar year of 1937.

At the present time there are no reliable estimates of the total number of all cancer cases in the United States; various estimates have been made, most of which range from 500,000 to 600,000 cases. If these estimates are at all correct and if the percentages quoted for the 4 cities hold true for the entire country, there would be from 15,000 to 20,000 cases of cancer of the bladder. This is a very rough estimate and cannot be regarded in any sense as an official statement.[1]

Serious and persistent work in controlling bladder cancer began perhaps 25 years ago. The methods used have been widely divergent and only loosely standardized. The passing years have seen many advances, the most important of which seems to be the realization of the seriousness of the disease and the difficulties besetting its control.

The work of control has had one peculiarity; it has been periodically interrupted by confusing periods of impotency. Methods have been tried, found inadequate, discarded, and calmly returned to after a period of forgetfulness. Exact pathological classifications have been made, generally accepted, then discarded in part as imperfect, and brought to light and prominence years later. Mistaken treatments have been persisted in over periods of years; significant and perhaps important leads have been unearthed, then casually not followed, and finally forgotten.

To be specific, Mendelbaum in a monograph from the Mt. Sinai Hospital accurately described, placed, and fixed various bladder tumors in their proper classification. This was done some 25 years ago. The main groups were then papilloma, papillary carcinoma, and infiltrating carcinoma. Most urologists have stumbled over the classification of a fourth group, the malignant papilloma or papilloma with atypical cells. However, after a period of uncertain groping, urologists have simplified matters and placed these under papillary carcinoma. With rare exceptions they behave clinically like papillary carcinoma and he who considers them such plays safe. Yet at a recent meeting of the American Urological Association grave doubt was raised. It was suggested that these "atypical papillomas" were no more malignant than papilloma and might be treated like the latter, namely, by fulguration.

Some years ago Counseller and Braasch from The Mayo Clinic published the results of diathermy on 17 patients with inoperable and nonresectable bladder cancers. They got an astonishing 88 per cent 5-year cures. This has never been duplicated. The results, as far as I know, have not been checked and they have never been followed up.

Nitze, 35 years ago, established that papilloma could be controlled by the cystoscopic application of heat. Beer popularized this by the fulguration method. Neither Beer nor anyone else considered that the fulguration or heat method could be applied to bladder cancer with any hope of cure. Heat has long been discredited as a means of dealing with any cancer. We all remember the Percy cautery operation for cancer of the uterine cervix. Yet since the popularity of the transurethral operation for hypertrophied prostates, the transurethral instrument has been used widely in an attempt to destroy bladder cancers, and I think we will all be somewhat aghast to consider the 5-year results of this method.

The difficulty in successfully treating a cancer of an internal organ such as the bladder occasions these cycles of confusion and doubt. The bladder

[1]These statistics are from a letter of Mr. Harold F. Dorn, statistician of the United States Public Health Service.

From Memorial Hospital.

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is a vastly important link in the sewerage disposal of the body; it is finely adapted to play its part of urinary reservoir; it intermittently empties itself, thus allowing undisturbed sleep and uninterrupted work; its lining cells resist secretion of urine; but if its function is disturbed or interrupted, serious results ensue.

If these cancers grew on the surface of the body instead of in the bladder, cure would be comparatively simple. It is their position in the bladder which causes difficulties. These difficulties, however, should not be insurmountable with the most efficient of all instruments devised for the surgeon, the cystoscope, and with the various devices at our disposal for examination of the bladder, kidneys, and ureters. An accurate estimate of the changes in the bladder, ureters, or kidneys caused by the tumor should overcome many of the obstacles of the internal position of the tumor.

There are, as far as I know, only two methods of dealing with true bladder cancer. One is the wide surgical removal as practiced and published by the late Edwin Beer and Verne Hunt, and the other method involves various forms of irradiation. It is not within the province of this paper to discuss the former.

Irradiation comprises external irradiation by means of high voltage roentgenographic machines and irradiation directly applied to the tumor by means of radium. Because most bladder tumors are radio-insensitive, high voltage irradiation has been of little value to date in the treatment of bladder cancers.

When we know more about handling the 1,000,000 kilovolt machines, we may have a valuable aid in treating the worst type of bladder cancers, namely, the highly malignant and extensively infiltrating type. At the present time we are able to control by intrinsic irradiation only about 1 out of 4 of these cancers.

I have analyzed 2 recent reports of the high voltage treatment of bladder cancers, that of Wirth, of Seattle, who used an 800,000 kilovolt machine and that of Dresser and Rude, of Boston, who used a 1,000,000 kilovolt machine. Both report interesting and significant results and some control of infiltrating tumors. The latter noted that if the high voltage be used properly the general reactions of patients are less than with the 200,000 kilovolt machine. In all of these reports the controlled patients have been observed less than 3 years.

Dean and the author have reported on a patient with a large infiltrating bladder cancer, grade III, radioresistant, treated with the 800,000 kilovolt machine. We wrote as follows: "At present thirty months after admission patient looks and feels well. Gained thirty pounds, bladder looks normal. No rectal induration." Yet this patient died 3½ years after first seen from extensive roentgenographic slough of the suprapubic region. Future work will be necessary to clarify the position of high voltage roentgenotherapy in the treatment of bladder cancer.

Radium treatment with all its disadvantages seems to me to be the most useful of all methods in the treatment of bladder tumors. It is flexible and can be used repeatedly through the cystoscope. When properly used suprapubicly, the immediate operative mortality should be around 6 per cent, or about half that of surgical removal. The implantation of radon seeds into a cancer covering the ureters causes less disturbance to the kidney function than the operative removal and re-implantation of the ureter into the bladder. If total cystectomy be excluded, radium can cope with much more extensive tumors than can surgery.

SUMMARY OF 5 YEAR RADIUM RESULTS

Up to and including the year 1934, all private patients treated by radium have been included in this report. These cases, 228 in number, have not been selected but have been consecutive cases which represent a cross section of bladder cancer. If the tumor has been confined to the bladder, no matter what its size, an attempt has been made to control it by radium. Both the cystoscopic and suprapubic methods have been used.

In order to compute the percentage of 5-year cures these 228 cases have been divided into 2 classes, 40 indeterminate and 188 determinate cases. The latter were used only to compute the 5-year results. In the determinate cases there are 2 groups. There are 71 patients who proved to be cured of cancer for 5 years; the second group, or 117, are those who died of cancer or who were lost track of. In the indeterminate class, there were 14 patients not treated by radium but in whom some palliative operation had been necessary. Twenty-six patients in the indeterminate group with bladder cancer had been cured but died from some other disease or were lost track of before the 5-year period had elapsed.

Among the determinate cases 71 patients or 37.8 per cent were well for 5 years; 117 or 62.2 per cent died of cancer. Therefore, the percentage of 5-year cures is almost 38 per cent.

Of the 228 cases 90 patients or 39.4 per cent had papillary cancer and 138 or 60.6 per cent had infiltrating cancer. No specimen was obtained in

22 instances and the clinical diagnosis was either papillary or infiltrating cancer. In the large majority of the cases the diagnosis was made from the pathological specimen. The specimens were always small and often taken with the cystoscopic rongeur. Because of this they did not always indicate the real diagnosis. If, for example, the pathologist reported papillary carcinoma and at operation a hard extensively indurated base was found, the tumor was classed as infiltrating carcinoma. Most of the tumors have been graded by the Carcinoma Registry and this has helped in distinguishing various grades of malignancy. When a small section of a tumor is obtained, as indicated above, we believe that the clinical examination and the pathological examination are of equal value in determining the diagnosis.

Radium alone in different forms has been used to control these tumors. For the most part the radium has been in the form of emanation gold seeds placed in the base of the tumor by needles. In 41 instances cystoscopic radium was employed and in 129 operative radium. A combination of the two procedures was used in 44 patients and 14 received no treatment whatever.

If the tumor in question was reasonably small and situated in a part of the bladder which could be reached adequately through the cystoscope, treatment through the cystoscope was relied upon. This was done whether the tumor was papillary or infiltrating. We have successfully extended the scope of this method to larger tumors in the last 5 years. It is the method of choice and, if it can be accomplished, saves time in the hospital, diminishes the hazards of operation, and minimizes bladder and kidney infection. It takes persistent, repeated, and intelligent cystoscopies. When the suprapubic method is used, the operation is simply a means to the end of implanting radon seeds into the tumor under direct vision. It is significant that in a fair percentage of cases both cystoscopic and suprapubic methods have been necessary to control the disease.

In 177 patients the location of the tumor was near the urethra or near one or both ureters. Those are regions favorable for cystoscopic manipulation. If the suprapubic implantation of radon seeds is indicated, this likewise is easily accomplished in those locations. The operative removal of a tumor adjacent to either ureters or the urethra is a complicated operation and usually involves the excision and re-implantation of a ureter into the bladder. This gives radium a marked tactical advantage over surgery. Forty-four of these bladder cancers were located either in the lateral walls or vault, and no mention is made as to the location of 7 cancers.

The base size of these 228 bladder cancers varied: 40 were less than 5 square centimeters; 56 ranged from 5 to 10 square centimeters; 39 were 10 to 20 square centimeters; and 86 were larger than 20 square centimeters. The size of 7 cancers was not estimated. This shows that 17 per cent of the cancers had bases between 10 to 20 square centimeters and 38 per cent had bases more than 20 square centimeters. It is obvious from this that these 228 cases were not picked cases.

ADVANTAGES AND DISADVANTAGES OF RADIUM TREATMENT

The most frequent complication of the implantation of radon seeds is stone formation on the base of the killed tumor. This can be controlled generally by cystoscopic means. Rarely is the condition serious enough to entail a suprapubic operation for the removal of the stone. Severe infection of the bladder and kidneys may occur and this is usually the cause of death in those patients who die the first year following treatment. Vesicorectal or vesicovaginal fistula has occurred several times and was equally due to the growth of the tumor through the bladder and to irradiation. As far as my long term judgment goes the disturbance to the kidneys from the irradiation of a tumor, directly over the ureteral orifice, is less than if the ureter be excised surgically and re-implanted into the bladder. Sometimes kidneys have been silently destroyed over a long period. Occasionally at the end of 5 or 9 years ureteral strictures have occurred. These have been controlled by ureteral dilatation. The implantation of radon seeds may cause dysuria of greater or less intensity.

With all its faults, however, the treatment of bladder cancer by means of radium seems to be the method of choice. It is very flexible; it can be used cystoscopically, as well as suprapubicly; if cystoscopically, there is no mortality from its use, and if implanted through the open bladder, there is an operative mortality of but 6 per cent; it apparently has a peculiarly selective effect upon cancers, and certainly 37.8 per cent of 5-year cures in unselected cases cannot be approached by any other method of therapy.

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MARCELLO MALPIGHI (1628-1694). Supplied missing fact in Harvey's theory of the circulation of blood by discovery of channel of blood from artery to vein; founder of microscopical anatomy; persecuted and molested by men who had remained disciples of Galen; physician to Pope Innocent XII.

Marcello Malpighi

1628-1694